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CLOTTED CREAM

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INTRODUCTION

The counties of Devonshire and Cornwall in England, have for generations been renowned for a particular variety of cream known as "clotted cream," "Devonshire clotted cream," the cream of 2000 years. As long ago as 1791 Twamley in a communication to the "Bath and West Society," says:

> From the method used of heating the milk, is produced what is called "clouted cream;" which I suppose should be termed "clotted cream," as the warmth causes the cheese particles to incorporate with the cream, makes it clot, and becomes more mucid or slimy."

In many parts of Canada, and the United States, there are great opportunities existing for the establishment of a new industry; one which would be a sound financial undertaking for the dairyman, and one which would be welcomed by the consumer. In the great fruit producing districts, and in the vicinity of large residential centers, and summer resorts, a constant supply of a first class clotted cream would rapidly create its own demand; would increase the interest of the consumer in the products of the dairy; and would be an industry returning an adequate profit to the farmer or dairyman who undertakes to pioneer and substantiate the production. It is quite feasible to prepare the cream on the farm or at the creamery or factory.

Little data has been published on the preparation of clotted cream, and while some text books, and also official leaflets of the Board of Agriculture, London, have embodied brief descriptions of a general method of procedure, there does not appear to have been any experimental work carried out with a view to the elucidation of a standard system, based on the many methods employed by the various makers. In 1912, I was deputed by the

college with which at that time I was connected—the Midland Agricultural and Dairy College, Kingston, Derby, England—to conduct an enquiry on behalf of the Board of Agriculture into the methods adopted by, and the conditions prevailing among, the makers of clotted cream. Some considerable time was spent among the producers of the cream, and subsequently an exhaustive series of practical experiments was conducted at the college at Kingston.

METHODS IN VOGUE

The method of preparation adopted by one of the large dairy companies in the city of Exeter, Devonshire, is as follows:

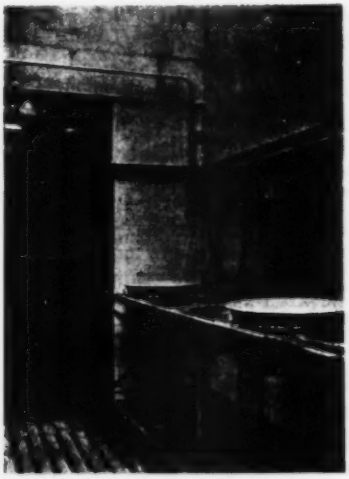

FIG. 1. STEAM SCALDING APPARATUS WITH TWO PANS OF MILK IN POSITION
The cooling room may be seen in the background.

The whole fresh milk is poured into shallow pans and after standing for some ten to twelve hours is scalded. For this purpose the dairies are fitted with long copper troughs to accommodate the water, and with steam connections for the heating; covers made of copper fit on the top, and these are hollowed in

FIG. 2. CLOTTED CREAM MAKING

View of interior of creamery, Aylesbeare, Devon.

FIG. 3. SOME OF THE UTENSILS USED IN THE PROCESS

Three-legged cream drainer; pan in which milk is set and scalded; skimmer; palette knife.

such a way as will admit of the pans being supported, and at the same time surrounded by the water. The steam is turned on and the water brought to the boiling temperature, when the pans are put on. The temperature of the milk and cream is not usually allowed to go higher than 190° F. and in about fifteen minutes the operation is completed. A thermometer is used, but experienced dairymen often tap lightly the rim of the pan, and if small bubbles rise on the surface of the cream, consider that the scalding is completed. The pans used are of such size as will deal easily with 2 gallons of milk.

FIG. 4. SKIMMING THE CREAM IN A WEST-COUNTRY DAIRY

From the scalding room, the pans are taken to a cooler room, and about twenty-four hours later the cream is taken off by means of specially adapted skimmers: they are long handled skimmers with small perforations, and by means of these the cream is lifted into a metal strainer, the bottom and sides of which are perforated in order to permit of the thinner cream passing away, leaving only the typical thick cream in the vessel. That which passes through the perforation is utilized for butter-making. The cream having been skimmed, is ready for sale at once. In Plymouth, a dairy dealing with the milk of 250 cows adopts

in its essentials, the same method; and the system with slight variations is common to many of the largest producers engaged in the industry.

FIG. 5. "FURNACE AND 'COPPER'"

Scalding apparatus as used in a well-known Newton Abbot Dairy.

Another well known maker uses a "copper," the water being heated by a furnace. The temperature of the water in the copper at the conclusion of the process is about 212° F., and the heating is conducted for from thirty to forty minutes. In North Cornwall, there are still to be seen one or two examples of the production of clotted cream where the heating is done by means of peat fuel cut from the moors on the homestead.

FIG. 6. OLD METHOD OF MAKING CLOTTED CREAM

EXPERIMENTS

Before commencing the experimental work, suitable utensils had to be obtained; and having in mind the principal methods adopted by the makers of clotted cream in the west of England, a form of apparatus embodying as far as possible the chief features of the best types in use was designed and fitted up in the

dairies at the college.[1] Briefly, the apparatus consists of a shallow galvanized iron tank raised on strong iron supports, the cover being of block tin with holes to receive the pans of milk. The pans are made of block tin, 20 to 24 inches diameter at the top, 12 to 14 inches diameter at the bottom and 8 inches deep. Water is contained in the tank and the heating effected by means of steam passing through pipes direct into the water, the conducting pipes being arranged in such manner as to avoid vibration. Usually the amount of milk set for creaming was 6 quarts to the pan.

The milk, as fresh as possible, having been poured into the pans, was allowed to stand for twelve to fifteen hours to ensure the rising of the cream. The scalding process was then proceeded with. The temperature of the water having been raised almost to the boiling point, the pans were put on, care being taken that the layer of cream should not be broken. At the beginning of the experimental work the scalding was allowed to take from fifteen to twenty minutes, and the temperature of the milk and cream when removed from the heating apparatus varied from 180° F. to 185° F. After the first four trials, a change was made by scalding from twenty-five to thirty minutes; this was continued throughout and the change was completely justified by the results. During the second half of the experiments, the temperature of the cream and milk at the conclusion of the scalding was 187°F. and it was then that the finest samples of cream were secured. At the conclusion of the scalding, the layer of the cream in the pan is crinkled, and appears as a "blanket" or "head" of cream on the surface of the milk, from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick. The pans were then removed and placed on shelves in a cooling room for from twenty to twenty-four hours. When cool, the blanket of cream was lifted with a skimmer and placed in a perforated strainer; this part of the process requiring careful attention, to avoid impairing the texture of the product.

[1] It has not been possible to obtain a photograph of the actual scalding appliance as used in the experiments. The apparatus was a combination of the appliances shown in figures 1 and 5.

From the strainer, the cream was packed as desired, and at once was ready for consumption.[2]

ANALYSES

The original milk, the clotted cream, and the resulting scald milk were weighed and submitted to analysis. For the analyses I am indebted to Mr. Alfred Appleyard, M.Sc. (now of the Rothamsted Experimental Station).

TABLE 1 (Percentages)

DATE	SAMPLE	MILK		SCALD MILK		CLOTTED CREAM
		Fat	Total solids	Fat	Total solids	Fat
1912						
July 20	1	4.10	13.18	0.80	10.25	59.69
July 21	2			1.00	10.41	58.97
July 22	3	4.05	13.03	0.80	10.12	56.76
July 23	4a	3.90	12.68	0.45	10.00	62.65
July 25	5a	3.35	12.61	0.60	10.11	62.61
July 25	6a	3.70	12.81	0.75	10.25	64.90
July 26	7a			0.75	10.19	66.27
July 28	8a	4.80	13.43	1.00	10.13	62.54
July 30	9b			0.70	10.41	63.47
July 30	9d			0.65	10.32	66.59
August 1	10a			0.50	10.00	62.59
August 1	10b			0.40	9.68	64.23
August 1	11a	4.30	13.24	0.90	10.21	64.10
August 2	12a	4.55		0.90	10.16	62.67
August 3	13a	4.70	13.53	1.05	10.25	64.72
August 4	14a	4.25	12.89	0.60	10.02	64.56
August 5	15a	4.50	13.07	0.70	9.97	59.47
August 6	16a	4.80	13.84	0.95	10.59	60.33

The average weight of clotted cream worked out at 10.39 ounces cream from 15 pounds milk, or 1 pound clotted cream from 23 pounds of milk.

[2] The preliminary cooling of the milk, and the cooling after the "scalding" may be hurried by placing the pans in an outer trough or pan through which cold water is continuously running.

Many adaptations of the method will suggest themselves, such being largely dependent upon local circumstances, prevailing equipment, and the quantity of the product it is proposed to place upon any particular market.

A reference to table 1 indicates that the percentage of butterfat in the original milk cannot have any considerable influence upon the percentage of butterfat in the finished cream, owing possibly to the method of skimming which at present prevails. Table 2 gives the complete analyses of the samples of cream; it will be seen that the percentage of butterfat in clotted cream may be as high as 66.59 per cent, the more usual percentage being however from 62 to 64 per cent.

TABLE 2 (Percentages)

Clotted cream

SAMPLE	WATER	BUTTER-FAT	SOLIDS NOT FAT	TOTAL SOLIDS	PROTEIN
1	35.46	59.69	4.85	64.54	3.07
2	33.05	58.97	7.98	66.95	3.00
3	37.29	56.76	5.95	62.71	3.45
4a	32.87	62.65	4.48	67.13	3.51
5a	31.03	62.61	6.36	68.97	3.58
6a	28.10	64.90	7.00	71.90	3.64
7a	27.94	66.27	5.79	72.06	3.19
8a	29.68	62.54	7.78	70.32	2.94
9b	28.15	63.47	8.38	71.85	2.62
9d	27.57	66.59	5.84	72.43	3.58
10a	30.18	62.59	7.23	69.82	3.26
10b	29.06	64.23	6.71	70.94	3.19
11a	30.40	64.10	5.50	69.60	3.26
12a	31.46	62.67	5.87	68.54	3.64
13a	27.87	64.72	7.41	72.13	3.45
14a	29.90	64.56	5.54	70.10	3.39
15a	33.28	59.47	7.25	66.72	3.77
16a	31.74	60.33	7.93	68.26	4.09

QUALITIES OF CREAM

As regards the qualities required in a typical sample of clotted cream, it must be granular in texture; it should be firmer than the thickest of cream obtained from a separator, but not so firm as a freshly made cream cheese; the colour should be golden, not unlike the colour of the butter made from pure-bred Guernsey cows. The cream must not be too wet or "mushy," or if so it ceases to be characteristic; moreover, if too much moisture is present it indicates an excess of scald milk incorporated in the

cream, and the keeping qualities are thereby considerably impaired. The cream must have a nutty taste, and a decided scalded flavour pleasing to the palate.

An important feature of the experimental work to be noticed was the breed of cows from which the milk was produced. The college herd was composed of Dairy Shorthorns; the herds of Devonshire and Cornwall were principally Jerseys, North Devons, South Devons, Guernseys, and various crosses. It has been said that typical clotted cream could only be made in Devonshire and Cornwall. To obtain information on this point, arrangements were made with two well known producers of clotted cream, Mr. A. O. Rowden of Exeter, and Mr. J. Dolbear of Newton Abbott, whereby the experimental samples of cream could be judged. The samples were posted to them as early as possible and would usually arrive some twenty-four to thirty-six hours after skimming.

Extracts from the reports of these gentlemen are as follows:

9d. . . . . best specimen yet seen . . . . granulation all right but lacks the characteristic flavour.

10a and 10b. . . . . samples 10a and 10b are the thing.

13a. . . . . typical . . . . after thirty-six hours still very nice and sweet.[3]

14a . . . . . all right and quite typical . . . . .

These reports would tend to show that breed of cattle and type of pasture have not the predominating influence which hitherto has been credited to them.

BACTERIOLOGICAL PROBLEMS

During the course of the investigation, a number of bacteriological problems suggested themselves; and of these the most important appears to be the explanation of the derivation of that unique flavour so characteristic of the best samples of clotted cream. While the actual scalding process is to a great extent responsible for the specific flavour, there is every reason to believe

[3] This would mean about seventy-two hours after packing.

that even before the scalding takes place, the flavour has in a great degree been decided. During the time which elapses between the setting of the milk for creaming, and the scalding, bacterial action is progressing and the various organisms present are exerting an influence upon the flavour of the milk itself. When the scalding begins, the currents which are set up in the milk and cream, tend to distribute the bacteria and bacterial products evenly throughout the whole, and the flavours which are the result of volatilization would probably be taken up and retained by the cream.

The scalding is essentially a system of pasteurization, the efficiency of which depends largely upon the types of bacteria which comprise the original flora of the milk. During the time elapsing between the scalding, and the skimming after cooling, the conditions would be such that the bacteria surviving might exert a further influence upon the flavour and quality of the cream. At the time the work was done, some support was lent to these contentions by the results of certain experiments of which mention is made in the original publication. The scope of the work did not however permit of bacteriological examinations, but the foregoing is included, as a rich field for investigation would appear to have presented itself.

SCALD MILK

Scald milk—the residual milk after the cream has been lifted —was formerly used almost exclusively for the feeding of calves. This by-product however is a commodity of very considerable food value, and in the west of England a profitable business has been established in the selling of the scald milk for human consumption and for cooking purposes. As will be seen—table 1—a high percentage of protein is available and the percentage of butter fat will average about 0.75 per cent.

SUMMARY

1. Enquiries have been conducted on behalf of the Board of Agriculture as to the methods adopted by the producers of 'clotted cream' in the counties of Devonshire and Cornwall.

2. Experiments have subsequently been undertaken at the Midland Agricultural and Dairy College, Kingston, Derby.

3. The results of these experiments thus far, tend to show:

a. That provided a suitable system be adopted and reasonable care be taken in management and manipulation, clotted cream having the typical and characteristic properties can be produced in any district.

b. That while a rich milk is preferable, it is not at all essential for the production of characteristic clotted cream to have only the breeds of cattle favoured by the producers in Devonshire and Cornwall.

c. That the flavour and keeping properties of the cream are problems of a bacteriological nature.

4. "Scalding" for twenty to thirty minutes with a final temperature of 187° F. proved to be a satisfactory procedure.

5. One pound of clotted cream was produced from 23 pounds of milk.

6. The average percentage of butterfat in the clotted cream was 62 to 64 per cent.

7. The average butterfat content of the scald milk was 0.75 per cent.

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EXPERIMENTS ON DETERMINATION OF COW MANURE IN MILK; MOISTURE CONTENT AND SOLUBILITY OF COW MANURE[1]

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A series of experiments was conducted on cow manure from the experimental farm at Beltsville, to determine primarily whether the manure in unstrained milk can be measured quantitatively by chemical methods. A method was found which gave good results provided the original quantity of manure present was fairly large. For average milks, however, this chemical method is impractical on account of the fact that while manure is always present, it is as a rule in such small amounts that it cannot be measured chemically.

It was found that a series of disks containing known amounts of manure could be made which will give fairly accurate results when compared with the sediment from milk after using the sediment tester, by means of a modified method. Since accurate determinations can be made only with unstrained milk, and since all market milk is strained there seems to be no simple practical method of determining the amount of manure present in milk. Along with this work, other experiments were made to determine moisture and solubility in water and milk of fresh and dry manure.

Composite samples of manure were collected at different times, covering a period of two months. The cows were fed bran, corn meal, cottonseed meal, and corn silage. The manure, fresh, was a heterogeneous mass, consisting of short straw and fiber, pieces of corn, mixed with a wet dark mass. The samples were well mixed, but not ground.

The moisture was determined by drying the fresh moist sample for five hours in an air oven at 98 to 100°C. The results together

[1] Published by permission of the Secretary of Agriculture.

with the approximate amounts taken for the determinations are shown below:

	per cent
Lot, using 5 grams wet material	84.24
	82.32
	83.89
	83.93
	83.72
	83.95
Lot, using about 2 grams wet material	81.85
	81.48
	82.11
	82.08
Lot, using from 0.5 gram to 6 grams wet material	82.61
	82.65
	83.22
	81.04
	82.00
Lot, using about 1 gram wet material	83.64
	82.80
	82.90
	82.99
Lot, using about 0.5 gram wet material	82.76
	82.36
Lot, using about 2 grams wet material	83.53
	84.60
Lot, using about 2 grams wet material	80.63
	80.33
Lot, using about 2 grams wet material	84.00

The average of twenty-six determinations was 82.76 per cent moisture in the fresh manure. This would leave an average of solid matter in the manure, 17.24 per cent.

The moisture content of the air-dried manure was also made. These determinations were made by drying in an air oven, 98 to 100°C., composite samples of manure which had been allowed to air dry at room temperature.

The results were as follows:

	per cent
Moisture	5.79
	5.91
	5.73
	5.86
	5.43
Average	5.74

This would leave for the air-dried manure a solid content of 94.26 per cent.

SOLUBILITY OF MANURE IN WATER

The dried manure solids were treated with distilled water; first, by transferring the material to a weighed filter and washing with water to clearness; secondly, by allowing the material to soak in water from one hour to eighteen hours and then filtering through either a weighed filter paper or a weighed cotton disk. The results obtained by these different methods are so nearly alike that the figures are combined to get the averages:

Solubility of solid matter in manure after drying to constant weight

CALCULATED ON WET BASIS		CALCULATED ON DRY BASIS	
Insoluble	Soluble	Insoluble	Soluble
per cent	per cent	per cent	per cent
14.28	1.48		
14.20	1.56	90.14	9.82
16.15	1.53	91.38	8.62
14.27	1.84	88.58	11.41
15.73	2.16	87.93	12.07
15.82	2.10	88.22	11.78
Ave., 15.07	1.78	89.25	10.74

Summarizing the results thus far obtained we get:

For fresh manure (averages)

	per cent
Moisture	82.76
Solids	
Water soluble	1.78
Water insoluble	15.07

For air dry manure (averages)

	per cent
Moisture	5.74
Solids	
Water soluble	10.12 (94.26 × 10.74)
Water insoluble	84.14 (94.26 × 89.25)

From these results we conclude that with a water solution of fresh manure, 84.54 per cent (82.76 + 1.78) will be in solution, leaving 15.07 per cent insoluble; while with an air dried manure, 15.86 per cent (5.74 + 10.12) will go into solution, leaving 84.14 per cent insoluble.

SOLUBILITY OF MANURE IN MILK

The method of determining solubility of manure in milk had to be varied from that used in determining solubility of manure in water on account of the fat and other solid matter in milk which might remain on the filter. The dried material after soaking in milk was transferred to a Gooch crucible with a cotton disk, washed with warm water followed by ether. Details of this method are given further on.

The dried manure was lumpy. These lumps were broken up but were not pulverized.

The results are as follows:

Solubility, in milk, of solid matter in manure dried at 100°C., for five hours

CALCULATED ON WET BASIS		CALCULATED ON DRY BASIS	
Insoluble	Soluble	Insoluble	Soluble
per cent	*per cent*	*per cent*	*per cent*
16.99	1.16	93.63	6.37
17.26	1.26	93.20	6.80
15.19(av.-3)	0.94(av.-3)	94.22(av.-3)	5.78(av.-3)
15.71	0.65	96.02	3.98
16.41	0.79	95.44	4.56
16.98	0.66	96.34	3.66
15.20	1.27	92.37	7.63
Ave., 16.25	0.96	94.46	5.54

Summarizing the results, we obtain the following:

For fresh manure (averages)

	per cent
Moisture	82.76
Solids	
Soluble in milk	0.96
Insoluble in milk	16.25

For air dried manure (averages)

	per cent
Moisture	5.74
Solids	
Soluble in milk	5.22
Insoluble in milk	89.04

From these results we can say that approximately 83.72 per cent of fresh manure is soluble in milk, leaving 16.25 per cent insoluble. On the other hand, with air dried manure, 10.96 per cent will go into solution in milk, leaving 89.04 per cent insoluble.

Comparison of the solubility of manure in water and milk shows the following results:

	SOLUBILITY IN	
	Water	Milk
	per cent	per cent
Fresh manure (82.76 per cent water)	84.54	83.72
Air dried manure (5.74 per cent water)	15.86	10.96

In general, manure in whatever condition is less soluble in milk than in water. Nearly all of the above determinations were made after allowing the foreign material to remain in contact with the milk or in water in bottles over night. Experiments show very little difference in the results by allowing the manure to remain in the milk or water different periods of time.

SUSPENDED FOREIGN MATTER IN MILK

Experiments were made to determine whether manure in bottled milk settled to the bottom of the bottle. Manure, both fresh and air dry, was added to pint bottles of milk and the material allowed to settle over night. A layer about 1 inch from

the bottom of the bottle was siphoned off, the sediment being collected on a Gooch crucible.

	RESIDUE ON BOTTOM	SUSPENDED MATTER
	per cent	*per cent*
Wet manure	88.25	11.75
	90.78	9.28
Air dried manure	94.97	5.03
	89.95	10.05
Average	90.99	9.02

These results vary considerably, but they prove conclusively that all of the sediment in milk is not visible—that some of it remains suspended in the liquid. It may be stated that approximately 90 per cent of the foreign solid matter in milk settles to the bottom of the bottle where it may be seen.

WORK ON CHEMICAL METHODS TO DETERMINE SEDIMENT IN MILK

Experiment 1

a. Pint bottle of milk, containing no sediment, filtered cold, through dried, weighed cotton disk in copper sediment tester; not washed, dried and weighed. Gain in weight (milk residue), 0.0630 gram.

b. Repeated washing with 50 cc., water, gain in weight (milk residue), 0.0360 gram.

c. Repeated washing with 100 cc. water, gain in weight (milk residue), 0.0320 gram.

d. Repeated washing with 200 cc. water, gain in weight (milk residue), 0.0370 gram.

Experiment 2

a. Pint bottles of clean milk to which were added 0.5 gram, dry extracted manure; mixed; allowed to stand; filtered cold through dried, weighed cotton disk in copper sediment tester, washed with 200 cc. water; dried. Gain in weight over original material (0.5 gram) (milk residue), 0.1460 gram, 0.1180 gram, and 0.1320 gram.

b. Repeated, following washing with 200 cc. water and 25 cc. ether. Average increase in weight over original weight, 0.0080 gram.

c. Repeated, using only 0.1 gram dry extracted manure, washing

with 200 cc. water and 25 cc. ether. Average loss in weight under original weight, 0.0092 gram.

Experiment 3

Different amounts of dry extracted manure were added to pint bottles containing clean milk. This was set aside over night. The material was warmed to about 45°C. (113°F.), filtered through dried and weighed cotton disks in weighed nickel Gooch crucibles, using slight suction.

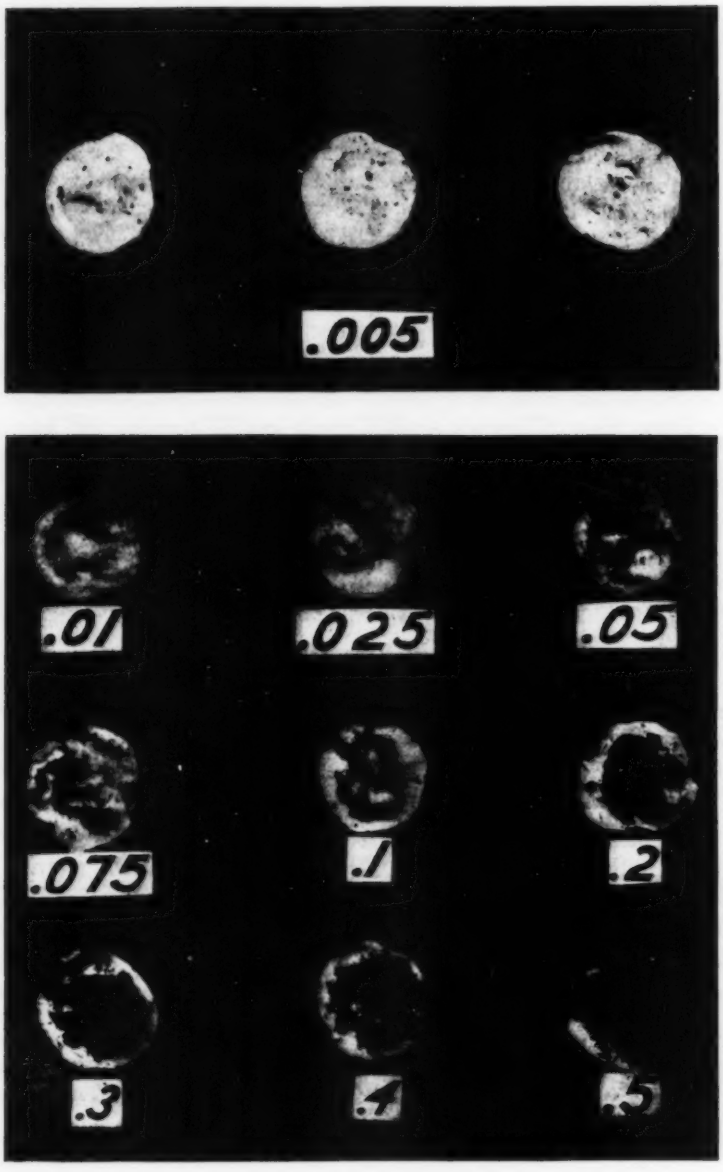
This material was washed with 200 cc. warm water, followed by 25 cc. ether, dried and weighed. Dry manure was used, but this was calculated to wet manure, using moisture factor of 82.8 per cent.

SAMPLE	USED		RECOVERED	LOSS OR GAIN
	Dry	Wet		
	grams	*grams*	*grams*	*grams*
(a).....	0.0860	0.5000	0.0810	0.0050 loss
(b).....	0.0688	0.4000	0.0675	0.0013 loss
(c).....	0.0516	0.3000	0.0480	0.0036 loss
(d).....	0.0344	0.2000	0.0320	0.0024 loss
(e).....	0.0172	0.1000	0.0275	0.0103 gain
(f).....	0.0129	0.0750	0.0170	0.0041 gain
(g).....	0.0086	0.0500	0.0095	0.0009 gain
(h).....	0.0043	0.0250	0.0070	0.0027 gain
(i).....	0.0017	0.0100	0.0070	0.0053 gain

Sample (e) is clearly off, and it is left out of the average. The amounts recovered vary from 5 mgm. below to 5 mgm. above the amounts used, the average loss and gain almost checking each other. It can be considered, therefore, that the above method is accurate to within 5 mgm.

The method outlined above (experiment 3) can be used only when milk contains more than 0.1 gram of wet (fresh) manure, as the error of 5 mgm. is too great when less manure is present. In actual practice, manure is seldom found above 0.1 gram in milk, consequently, this method is inapplicable for average amounts of manure present in milk.

Twenty-eight samples of unstrained milk were examined by this method. Quantitatively, they varied from 2 to 20 mgm. Physically, they showed no such variation, as there seemed to

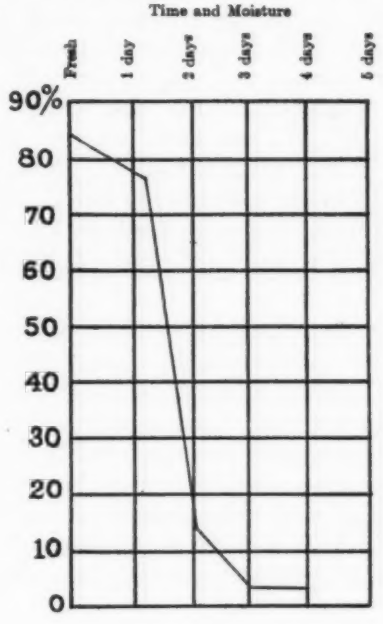


SHOWING VARYING AMOUNTS OF DIRT IN UNSTRAINED MILK.

be only a trace of manure in each disk. Compared with standard disks, there are less than 0.8 mgm. of manure, being one-third to one-twenty-fifth of the amount found quantitatively. A series of twelve cotton disks were prepared, showing quantities of wet manure from 0.5 gram to 0.005 gram. The increase in amounts was well shown on these disks and they were photographed. It is thought that they will, in a measure, indicate the amount of manure present in unstrained milk. Clean unstrained milk shows only traces of residue that might be laid to manure. It does contain cow hairs and white flakes which appear to be epidermis cells from the udder.

These disks show amounts of manure, calculated to a wet basis, placed in milk and filtered through cotton disks. The residues were washed with 200 cc. of warm water followed by 25 cc. ether.

The following diagram shows the rate in percentage of moisture and time of manure spread out to air dry:



Manure present in unstrained milk in quantities greater than 0.1 gram may be fairly accurately determined by filtering through a cotton disk and washing with 200 cc. water, followed by 25 cc. ether. Both the milk and the water should be warmed to about 45°C. before filtering. The disk should be dried and weighed before and after filtration. Manure present in unstrained milk in smaller quantities may be determined by filtering through cotton disks and comparing with standard prepared disks containing known amounts of manure.

It must be admitted that the results obtained are only approximate for dairy cow manure. However, considering the heterogeneous composition of this material the averages found are believed to represent the facts fairly well.

SUMMARY

The moisture in the cow manure examined averaged nearly 83 per cent. Air dry manure contains about 6 per cent of moisture; 5 per cent of the remaining solid matter is soluble in milk. This would indicate that only 11 per cent of dry manure dissolved in milk, 6 per cent of this being water.

Nearly 85 per cent of fresh cows' manure will dissolve in milk, 83 per cent of this being moisture. Manure in whatever condition is less soluble in milk than in water. Of the manure present in bottled milk, 91 per cent will be visible on the bottom of the bottle, leaving 9 per cent of foreign matter in suspension.

PRELIMINARY NOTE ON CERTAIN CHANGES IN SOME OF THE NITROGENOUS CONSTITUENTS OF MILK CAUSED BY BACTERIA

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The data presented herein is the result of a preliminary investigation on certain quantitative changes in the nitrogenous constituents of milk caused by bacteria before any change in the physical appearance of the milk is evident. The plan of the analyses was one of fractional precipitation by various precipitating reagents and the subsequent determination of the nitrogen in each of the fractions.

METHODS

Bacteriological. Accurately measured 50 cc. quantities of sterile skimmed-milk were placed in glass stoppered bottles and inoculated with a small amount of a watery suspension of the specific organism. The inoculated milk was then incubated at 30°C. for twenty-four hours. The number of organisms per cubic centimeter was determined by the plate method immediately after inoculation and at the end of the incubation period just prior to the beginning of the chemical analysis.

Chemical. The following plan of analysis was applied to each lot of milk just before inoculation and again at the end of the incubation period:

The total nitrogen was determined by the Kjeldahl method, a 5 cc. sample being used. Fiftieth normal sodium hydroxide was used for titrating the excess tenth normal acid.

The casein was precipitated by diluting 10 cc. of the sample with 70 cc. of distilled water and precipitating with 1.5 cc. of 10 per cent acetic acid at 40°C. The precipitate after settling out was filtered upon an ammonia-free filter paper until the filtrate was clear. The casein was then washed with acidified water until the filtrate and washings amounted to about 100 cc. The

filter paper was then transferred to a Kjeldahl flask and the nitrogen determined as for total nitrogen.

The filtrate obtained from the casein fraction was used for the precipitation of the albumin. About one gram of sodium chloride and one or two drops of phenol-phthalein were added to the filtrate and the mixture slowly heated to the boiling point and held for two minutes. During the heating concentrated sodium hydroxide was added until the mixture was neutral or slightly alkaline as indicated by a faint pink color. The same degree of color was maintained during the boiling period. This precipitation of the lactalbumin in neutral solution as recommended by Van Slyke and Hart (1902) gave satisfactory results in fresh milk but in many instances where marked decomposition of the casein had taken place a complete precipitation could not be obtained (5). Due to this fact a 10 per cent solution of colloidal iron (dialyzed ferric hydroxide) was used in all determinations. While the mixture was still hot 4 cc. of the colloidal iron was added drop by drop and the mixture gently shaken after each addition. The precipitate upon settling was filtered, washed and the nitrogen determined as noted above. The colloidal iron precipitated any albumin remaining in solution, it also brought down any other colloidal material which was present (1). As will be shown later this fraction contains other substances than the lactalbumin. The method however, gave comparative results which were desirable for this work.

Non-colloidal nitrogenous materials precipitated by phosphotungstic acid were included in the next fraction. This reagent will precipitate from acid solution; peptones, nitrogen bases including ammonia and the diamino acids (2). To the filtrate from the albumin fraction 0.5 cc. of 50 per cent sulphuric acid was added and then phosphotungstic acid drop by drop until no more precipitate appeared. The precipitate was allowed to settle out for twenty-four hours and then it was filtered upon a small ammonia-free paper. The filter paper and precipitate were dried in the air and transferred to a small evaporator where exactly 6 cc. of chemically pure concentrated sulphuric acid were added. The acid and paper were brought into intimate

contact by constant use of the stirring-rod until digestion had gone far enough to give a uniform mixture. An aliquot part of this mixture (2 cc. measured with an Oswald pipette) was used for the nitrogen determination by the Folin-Farmer microchemi-

TABLE 1

Table showing the changes in nitrogen content of the various fractions caused by different species of bacteria. Results are expressed as milligrams of nitrogen per 100 cc. of milk

ORGANISM	TOTAL NITROGEN	CASEIN NITROGEN		ALBUMIN FRACTION NITROGEN		PHOSPHOTUNGSTIC ACID FRACTION		AMMONIA NITROGEN		SOLUBLE NITROGEN OTHER THAN AMMONIA	
	mgm.	*mgm.*	*per cent*	*mgm.*	*per cent*	*mgm.*	*per cent*	*mgm.*	*per cent*	*mgm.*	*per cent*
Sterile	481.34	422.37	87.6	42.54	8.81	2.02	0.41	2.45	0.50	11.60	2.67
Bact. lactis acidi	481.34	408.82	84.0	46.94	9.70	1.40	0.29	2.46	0.51	21.72	5.50
Mic. albidus	481.34	422.91	87.8	40.31	8.16	2.29	0.47	2.92	0.60	12.91	2.97
Sterile	503.89	442.33	87.7	36.28	7.19	2.09	0.41	1.73	0.37	21.46	4.25
Ps. liquefaciens	503.89	446.90	88.7	35.16	6.97	2.12	0.41	1.53	0.30	18.18	3.63
B. lactis viscosus	503.89	438.85	87.0	42.12	8.35	2.91	0.57	1.70	0.33	18.31	3.67
B. mycoides	503.89	417.80	82.9	55.48	11.01	4.87	0.96	7.74	1.53	18.00	3.60
Acid peptoniser (species unknown)	503.89	435.93	86.5	41.61	8.25	2.00	0.39	3.00	0.59	21.35	4.26
Bact. bulgaricum*	503.89	430.14	85.3	30.31	6.01	6.11	1.21	1.69	0.33	35.64	7.09
Sterile	457.02	396.17	86.7	53.25	11.65	1.90	0.41	1.01	0.22	4.69	1.04
B. coli communior	457.02	394.55	86.3	44.21	9.67	2.25	0.49	8.74	1.91	71.60	1.60
Bact. aerogenes	457.02	391.34	85.6	48.89	10.69	1.72	0.37	10.73	2.10	4.27	1.90
Sterile	495.51	435.65	87.9	37.40	7.48	1.88	0.37	0.36	0.07	0.34	4.17
B. prodigiosus†	495.51	383.62	76.8	64.25	12.98	12.01	2.42	1.33	0.26	24.22	7.54
Ps. pyocyaneus	495.51	398.76	80.5	56.02	11.10	7.17	1.44	1.99	0.40	31.30	6.57
Sterile	462.45	390.69	84.5	50.46	10.90	1.55	0.33	1.47	0.31	37.57	3.98
B. subtilis	462.45	288.96	62.5	133.36	28.81	9.77	2.11	2.15	0.46	18.28	6.14

* This organism was incubated at 37°C. The milk was coagulated at the time of analysis.

† The milk was coagulated at the time of analysis.

cal method (3). The ammonia was aspired into hundredth normal acid and the excess acid titrated with five hundredth normal alkali. Methyl-red was used for the indicator.

The free ammonia was determined in 4 cc. quantites of milk

by the microchemical method of Folin and MacCallum (4). In this determination as in the above the weak standard acid and alkali were used instead of the colorimetric method.

The soluble nitrogen compounds other than those included in the foregoing fractions were calculated by difference.

CHEMICAL DATA

All determinations were made in duplicate and the necessary checks made upon the various reagents and materials used.

TABLE 2

Table showing the number of organisms before and after incubation, the number of generations produced by each species and the average number of organisms existing for the twenty-four hour period

ORGANISM	NUMBER OF ORGANISMS PER CUBIC CENTIMETER		NUMBER OF GENERATIONS	AVERAGE NUMBER ORGANISMS PRESENT FOR THE TWENTY-FOUR HOUR PERIOD
	Before incubation	After incubation		
1. Bact. lactis acidi	18,000	390,000,000	14.32	54,500,000
2. Mic. albidus	650,000	20,000,000	4.92	8,000,000
3. Ps. liquefaciens	1,850,000	360,000,000	7.94	90,400,000
4. B. lactis viscosus	16,700,000	100,000,000	2.49	73,600,000
5. B. mycoides	220,000	25,000,000	6.77	7,350,000
6. Acid peptonizer	5,350,000	540,000,000	6.57	163,600,000
7. Bact. bulgaricum				
8. B. coli communior	11,000,000	710,000,000	6.00	234,800,000
9. Bact. aerogenes	420,000	1,270,000,000	11.47	221,400,000
10. B. prodigiosus	6,400,000	520,000,000	6.27	164,800,000
11. Ps. pyocyaneus	2,680,000	500,000,000	7.45	133,900,000
12. B. subtilis	150,000	50,000,000	8.30	12,000,000

Table 1 gives the averages of the net duplicate determinations from the above procedure. The various lots of sterile milk are samples taken at different times.

BACTERIOLOGICAL DATA

The chemical data gives the relative change in nitrogen content of the various fractions but does not truly indicate the fermentative capacities of the various organisms. The following bacteriological data is included in order to give an idea as to the

relative number of organisms responsible for the changes indicated in table 1. In this paper no attempt will be made to correlate chemical decomposition with the bacterial content of a marketable milk. Such information must remain for future study.

In table 2 the number of generations and the average number of organisms existing for the twenty-four hour period were calculated by application of the following formulae:

(1) Formula for calculating the number of generations.

$$N = \frac{\text{Log } (B/A)}{\text{Log } 2}$$

N = Number of generations
A = Initial count
B = Final count

(2) Formula for calculating the average number of organisms existing for the twenty-four hour period.

$$P = \frac{(B \times R) - A}{(R - 1) \times N}$$

P = Average number of organisms existing for the twenty-four hours
R = 2 (Ratio of the progression)
N = Number of terms in the progression. (Number of generations)
A = Initial count
B = Final count

COMMENTS

In many instances the changes in the nitrogen content of the various fractions are so slight that they do not merit comment at this time. Many of the results however, are beyond the realm of experimental error and it is believed that they are worthy of attention. A study of table 1 will reveal the following general results:

All organisms tested except two cause a decrease in the casein fraction and in most cases this decrease is more marked with those organisms known to possess extreme proteolytic proper-

ties. Since each determination was made in the same manner, the results show relative changes by each of the cultures which have altered the precipitation of casein with dilute acetic acid.

The albumin fraction contains not only lactalbumin but any other colloidal material which may have been present. This is evident from the fact that with seven of the organisms there is an increase in this fraction. It is also apparent that in those cases where the albumin fraction has increased the casein fraction has materially decreased although the increase in the former is not equal to the decrease in the latter. This would seem to indicate that a part of the casein remained as a colloidal proteose which was not precipitated by acetic acid but was brought down by the colloidal iron. The data obtained does not show to what extent the albumin itself has been acted upon in such cases. The results obtained from the five remaining organisms show a decrease in the albumin fraction and in four instances there is little or no decrease in the casein fraction. This would seem to indicate that these species could attack the albumin more readily than the casein.

The changes in the nitrogen content of the three lower fractions are of particular interest inasmuch as they include compounds low in the scale of protein decomposition. It is quite possible that the substances in two of these fractions are responsible for some of the undesirable effects of bacterial action on milk, inasmuch as some of the organisms showing the most marked changes are commonly found in milk in appreciable numbers.

Although the bacterial content of the milks used for these analyses was far in excess of that found in a marketable product, the changes produced under these conditions serve as a preliminary basis upon which further work is contemplated.

ACKNOWLEDGMENT

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TALLOWY BUTTER—ITS CAUSES AND PREVENTION

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RANCIDITY AND TALLOWINESS

Rancidity and tallowiness are flavor and odor defects of butter which are generally attributed to the decomposition of the butterfat. Owing to the fact that the scientific investigator generally is not and does not presume to be, a butter judge, and therefore is not in a position to recognize and describe flavor defects of butter such as the butter expert knows them, no sharp distinction has heretofore been made in the description of experimental results dealing with these two butter defects. This has often resulted in the use of the terms rancidity, and tallowiness as synonyms. This confusion has been further aggravated by the fact that both of these flavor defects are often found in the same piece of butter. The inaccurate use of these terms is unfortunate, inasmuch as it has led to misleading interpretation of the causes of the defects which they describe, and has rendered difficult successful efforts towards their prevention.

The bulk of experimental data available shows conclusively, that rancidity and tallowiness are the result of entirely dfferent causes, rancidity being the result of hydrolysis and tallowiness being caused through oxidation. Under ordinary conditions, the hydrolysis leading to rancidity, is accomplished only by the action of ferments, while the oxidation is strictly a chemical action.

Jensen (1) and other investigators have shown that certain species of bacteria, and molds when inoculated into butter cause the butter to become rancid. The development of rancidity in these cases was accompanied by a marked increase in the acid value of the fat, showing that the rancidity was due to the formation of free fatty acids by hydrolysis of the fat.

Ritsert (2) demonstrated that these same organisms, when inoculated into pure butterfat, do not produce rancidity. This he

found to be due to the fact that the microorganisms failed to develop and rapidly disappeared, evidently because pure butterfat lacks the necessary food elements, salts sugar and protein, for bacterial growth. On the other hand, Duclaux (3), by the exposure of pure butterfat to air and light, obtained tallowy flavor and odor, in the fat. The development of tallowiness occurred without change in the acid value, but with a decrease in the iodine absorption number.

These results, which have been amply corroborated by other investigators can leave no doubt as to the difference between tallowiness and rancidity, and they definitely show that the solution of the causes and prevention of tallowy butter deals with problems foreign to those problems which have to do with rancidity.

TALLOWY BUTTER

Description of butter defect. Butter which is termed tallowy has a distinct taste and odor of spoiled tallow and usually is bleached in color, or entirely white Very old tallowy butter may change to a pinkish brown color. Tallowiness is a defect which renders butter utterly unfit for the market.

Occurrence of tallowy butter. Butter may and frequently does develop a tallowy flavor and odor and a white color within a few weeks of manufacture, though this defect usually requires from three to six weeks to become pronounced. Tallowiness is not a usual cold storage defect of butter. In cold storage, butter hardly ever goes tallowy. This defect develops primarily in butter laying in the stores and exposed to rather high temperatures (room temperature). Tallowiness is more prevalent in print butter than in tub butter and both the development of the tallowy flavor and the bleaching, start on the surface of the butter and gradually work into its interior. Butter may have turned perfectly white and tallowy on the outside, while its core may still have the normal yellow color and be free from the tallowy flavor.

Characteristics of butterfat from tallowy butter. When solidified the pure fat of tallowy butter has a lard-white color; when melted

it is a clear, almost colorless oil, similar to separator oil, and entirely unlike the golden yellow oil of normal butter. The odor of the fat is strongly tallowy, resembling old tallow.

When distilled with steam, the melted fat from tallowy butter did not relinquish its intense tallowy odor. The odor remained in the residue, it was intensified and more clearly tallowy. This was due, in all probability to the expulsion from the fat, by steam distillation, of butyric or other volatile acids and odors.

The distillate of the steam distillation of the fat from tallowy butter had not the faintest tallowy odor, showing that the tallowy odor cannot be distilled over by steam, but remains in the residue and this residue, being purified of other volatile odors, such as those of the free fatty acids, is very clear, and intense in its tallowiness. The distillate gave a faint reduction with silver oxide. This might be due to the formation of an aldehyde or of formic acid from the breaking down of the lactose in the butter. The reaction product of this formic acid may be the substance which causes the tallowy odor.

Further evidence of the presence of aldehydes in this tallowy fat is the interesting fact that, although the fat itself is of much lighter color than the fat of the same butter before the butter turned tallowy, the tallowy fat, upon saponification, gave a dark yellow soap, while the fat of the normal butter yielded a soap with a clear straw color. This may be explained to be due to the reaction of an aldehyde with the alkali.

The tallowy butter in a very advanced stage, gradually surrendered its whiteness and turned pink to brown. This brown color is not soluble in the fat, since after filtering, the fat is perfectly clear and entirely free from the brownish color. The water extract from the brown, tallowy melted butter, is also slightly colored and the curd of the same butter is chocolate brown. This indicates that this coloration is very slightly water-soluble and that it is absorbed by the curd. This brown color could not be removed from the curd by washing.

In experiments in which pure butterfat only was used, the samples failed to turn brown with age, the tallowy samples remained white. However, in those experiments in which casein

was incorporated in the pure butterfat, a brownish color always developed with an advanced state of tallowiness. This again suggests that there is an action on the curd in very advanced stages of tallowy butter.

The fat of the tallowy butter appeared to be more crystalline than that of normal butter, and at the same temperature there was a larger precipitation of the high-melting fats. This fact was further borne out by the higher melting point of the tallowy fat as may be noted in table 7.

CONDITIONS WHICH PRODUCE TALLOWY BUTTER

Jensen (1), Duclaux (4) and Browne (5) have independently and conclusively demonstrated that butter and also pure butterfat will turn tallowy by prolonged exposure to atmospheric oxygen and that the development of tallowiness is greatly hastened and intensified in the presence of direct sunlight or at a high temperature (room temperature or above) or both. These investigators show that the chemical changes which occur in the presence of air, light and heat, and which are accompanied by the tallowy taste and odor in butter and in pure butterfat, involve oxidation of the fats, primarily the olein, as indicated by the reduction of the iodine number. Browne further found a marked increase in the acid value which would suggest hydrolysis of the butter fat, producing free fatty acid, and an increase in the Reichert Meissl number, indicating either a breaking-down of the acids of higher molecular weight, or the oxidation of the glycerol, freed by the hydrolysis of the fats, producing formic acid. The probability of the oxidation of the glycerol is substantiated by the fact that, in the case of four samples of so called rancid butter, Browne found a reduction of the amount of the glycerol. Unfortunately, from the standpoint of their consideration here, the results of Browne lack essential information concerning exact temperature and other conditions under which his samples were kept, and it is not clear from his report which of the samples are comparative.

Jensen also recorded a marked decrease in the iodine number and an increase in the acid value in samples of fat from tallowy butter. He attributed the tallowiness to the oxidation of the

olein, on the strength of the decrease of the iodine number, and holds that the increase of the acid value is due to hydrolysis of the fat, as the result of bacterial action in the butter. Duclaux and Mjoen (6) also showed a decrease in the iodine number and of the free fatty acids of butter that had become tallowy upon exposure to air and light.

It appears from the above that it has been the general tendency on the part of these investigators to endeavor to prove that tallowiness is the direct result of oxidation of the oleic acid, as expressed by the iodine absorption number. And, in order to demonstrate the correctness of this assumption, the samples of butterfat used were exposed to most unusual conditions of temperature, light and air. But even under these abnormal conditions, there is room for reasonable doubt that the results obtained bear out the conclusion drawn. It has by no means been conclusively proven, that the oxidized oleic acid, as expressed by the decrease in the iodine number, is the cause of the tallowy odor and flavor, and it is not improbable that the oxidation of the oleic acid is only coincident with tallowiness. While in many cases tallowiness may be accompanied by the oxidation of oleic acid, in other cases, tallowiness may occur without appreciable change in this fat constant. This is strongly suggested by the results obtained by Hunziker, Spitzer and Mills (7), shown in table 1.

Lewkowitsch (8) and Dyer (9) hold that olein is very difficultly oxidized and the former believes that it is the action of the oxygen of the air and of the light on the free fatty acids which causes "rancidity" (rancidity here probably means tallowiness). Duclaux has also shown that the acids present, other than oleic acid, are split off in the proportion in which they are contained in the glycerides. It will be observed in table 8, that butterfat which was intensely tallowy, showed no appreciable change in the acid value. Shaw and Norton (10), as the result of experiments with renovated butter, conclude that the butter oil may be blown at a temperature that will insure its pasteurization, without impairing, in any way, the flavor, grain, or keeping quality of the finished product, This would obviously be impossible, if tallowiness were strictly due to oxidation of the fat.

TABLE 1

Showing average butterfat constants in butterfat from twelve separate churnings. These figures show the averages of the constants in the fresh fat and in the fat after eleven months' storage at room temperature

AGE OF FAT	AVERAGES OF TWELVE SAMPLES OF BUTTERFAT WHEN FRESH AND AFTER ELEVEN MONTHS STORAGE							
	Reichert Meissel number	Iodine number	Insoluble acids	Soluble acids	Saponification value	Melting point	Acid value	Refractive index
			per cent	*per cent*		°C.		
Fresh	29.177	36.093	87.892	6.073	229.316	33.648	1.391	44.155
Eleven months	29.645	35.971	88.289	6.206	231.673	33.367	2.235	43.608
Difference	+0.468	−0.397	+0.397	+0.133	+2.357	−0.281	+0.844	−0.547

All the samples of fat when fresh were perfectly sweet and normal in flavor. After eleven months storage at room temperature they were intensely tallowy. The above figures show that the tallowy flavor was not accompanied by any appreciable decrease in the iodine number.

It should be clearly understood in this discussion of the causes of tallowy butter, that neither the reduction of the iodine number, nor the production of a tallowy odor and flavor under these conditions of exposure to air, light and high temperature, furnish any tangible solution for the prevention of tallowy butter made and handled under commercial conditions. It is a fact well known to the butter manufacturers that air, light and heat produce tallowy butter, and in the manufacture and handling of commercial butter these agents are automatically guarded against. These factors do no longer jeopardize the quality of the butter, with the possible exception of butter made on the farm and of careless handlng in retail stores. Over the latter condition the manufacturer seldom has control, but even in the majority of these stores the butter is not subjected to conditions as severe as those which accompanied the bulk of the experiments above described. In fact the great majority of stores handle their butter in iced refrigerators.

The agents which render commercial butter tallowy must, therefore, be other than mere abnormal exposure to air, light and heat. There are oxidizing conditions other than light, air and heat, with which cream and butter come in immediate contact during the process of manufacture and there are other substances

in butter, than the olein of the fat, which may and do yield to oxidation and the products of which might well cause this tallowy odor and flavor.

Experiment with iron and copper. One of the first oxidizing conditions which suggested itself is the presence of metals and their oxides, as oxygen carriers, or by other catalytic action. Two of the most active common metals with which cream and butter come in contact are iron and copper.

In order to determine the power of these metals to make butter tallowy, a sample of fresh, normal butter was divided into three portions. These portions were placed in three petri dishes with covers. To one portion were added two rusty iron nails, in the second portion was imbedded a short piece of copper wire, the third porton was used as a check, no metal being added to it. The three petri dishes containing these portions of butter were covered, and stored at room temperature (65 to 75° F.) in the dark. The samples were prepared March 16 and examined April 20, May 15, and June 15, respectively, with the following results.

TABLE 2

Showing effect of contact with iron and copper on the flavor of butter held at room temperature in closed receptacles in the dark

DATES OF EXAMINATIONS	FLAVOR, ODOR AND COLOR OF BUTTER		
	Check	With iron nails	With copper wire
April 20....	Normal	Immediately around the nails butter was white and had tallowy taste and odor	Immediately around the wire butter had greenish tint with white border. Taste and odor were tallowy
May 15.....	Normal	Large circle of white. Flavor and odor very tallowy	Green directly around wire. White area increased and went deeper. Flavor and odor very tallowy
June 15.....	Normal	Entirely white. Flavor and odor very tallowy	Pinkish brown. Flavor and odor very tallowy

The above results show clearly that direct contact of the butter with either iron or copper developed a tallowy flavor and odor

and turned the butter white. In the case of the copper the white color was gradually superceded by a pinkish brown color.

The action started on the surface exposed to the air and gradually went through the entire mass of butter. The action of the copper was apparently much more rapid and more intense than that of the iron.

Experiment with iron hydroxide and copper hydroxide. The above experiment was repeated, but instead of using the metals of iron and copper, the hydroxides of these metals were used. In this trial four drops of a colloidal precipitate of iron hydroxide and of copper hydroxide respectively, was added to samples of 180 grams of butter. The results of this test are shown in table 3.

TABLE 3

Showing effect of hydroxides of iron and copper on flavor, odor and color of butter, made June 7, and kept in the dark

DATES OF EXAMINATIONS	NUMBER OF SAMPLES	FLAVOR, ODOR AND COLOR OF BUTTER		
		Check	Butter plus iron hydroxide	Butter plus copper hydroxide
Kept at 65° to 75° F.				
June 15	a	Normal[1]	Normal	Tallowy and bleached
	b	Normal	Normal	Tallowy and bleached
	c	Normal	Normal	Tallowy and bleached
July 7	a	Normal	Normal	Tallowy and bleached
	b	Normal	Normal	Tallowy and bleached
	c	Normal	Normal	Tallowy and bleached
August 9	a	Normal	Normal	Tallowy and bleached
	b	Normal	Normal	Tallowy and bleached
	c	Normal	Normal	Tallowy and bleached
Kept at 32° F.				
July 7	a	Normal	Normal	Tallowy and bleached
	b	Normal	Normal	Tallowy and bleached
	c	Normal	Normal	Tallowy and bleached
August 9	a	Normal	Normal	Tallowy and bleached
	b	Normal	Normal	Tallowy and bleached
	c	Normal	Normal	Tallowy and bleached

[1] The term "normal" refers in all cases and in all tables to the absence of tallowy flavor.

The results in table 3 show similar changes as those in table 2. The butter containing copper hydroxide went tallowy and turned white in one week at room temperature. At 32° F. the action required one month. The iron hydroxide however, failed to produce changes in the butter, the samples so treated remained normal throughout the period of the experiment, again emphasizing the lesser action of the iron and especially in the form of iron hydroxide.

Experiment with hydroxides of iron, copper, nickle and tin, and also the mixed hydroxides derived from brass and german silver, respectively, in the presence of lactose, curd, alkali and acid respectively, in butter and in butterfat. In this experiment, the effect on the flavor, odor and color of butter and butterfat, in the presence of iron, copper, brass, german silver, nickle and tin was determined. Part of the butter was made acid to the extent of 0.4 per cent with lactic acid, to another part enough alkali was added to make the butter contain 0.4 per cent sodium hydroxide. Also to pure butterfat treated with the above metallic hydroxides was added 1 per cent lactose and 0.4 per cent sodium hydroxide, and 1 per cent casein and 0.4 per cent sodium hydroxide, respectively.

In the case of the butterfat with lactose and alkali, the fat was filtered and washed, then to 100 cc. of the melted fat was added 14 cc. water containing 1 per cent lactose and 10 cc. normal sodium hydroxide. The sample was then emulsified by shaking while cooling in water, until congealed.

In the case of the butterfat with casein and alkali, to 100 cc. of the melted fat was added a solution of 1 gram of casein plus 10 cc. of normal sodium hydroxide. The results are shown in table 4.

Table 4 brings out the following interesting facts:

Pure butterfat containing a slight excess alkali and to which lactose had been added, bleached and turned tallowy at room temperature in the dark in two days After three additional days at room temperature and twenty-three days at 32° F. it was very tallowy and white. These changes occurred both in the presence and absence of metals.

TABLE 4

Showing action of hydroxides of six metals and alloys in acid and alkaline butter and in alkaline butterfat, in the presence and absence of lactose and curd. Samples prepared July 12, 1917, stored at 65° to 75° F. till July 17, and then at 32° F. until August 9

HYDROXIDES OF METALS AND ALLOYS USED	DATES EXAMINED	BUTTER			BUTTERFAT	
		Check	0.4 per cent acid	0.4 per cent NaOH	°0.4 per cent NaOH, 1 per cent lactose	0.4 per cent NaOH, 1 per cent casein
No metal...	July 17	Normal	Sour, slightly bitter, normal	Slightly soapy, normal	Bleached and tallowy	No characteristic taste
	August 9	Normal	Normal	Normal	Very tallowy, white	Bad flavor, normal
Iron.....	July 17	Normal	Sour, normal	Slightly soapy, normal	Tallowy and bleached	Slightly tallowy
	August 9	Tallowy	Normal	Normal	Very tallowy, white	Normal
Copper.....	July 17	Slightly bleached	Normal	Slightly fishy	Tallowy and bleached	Slightly tallowy and bleached
	August 9	Very tallowy, slightly bleached	Slightly tallowy, slightly bleached	Tallowy, bleached	Very tallowy, white	Tallowy, bleached
Brass.....	July 17	Slightly bleached	Normal	Normal	Tallowy and bleached	Slightly tallowy and bleached
	August 9	Very tallowy, slightly bleached	Slightly tallowy, slightly bleached	Tallowy, bleached	Very tallowy, white	Tallowy and bleached

TABLE 4—Continued

Showing action of hydroxides of six metals and alloys in acid and alkaline butter and in alkaline butterfat, in the presence and absence of lactose and curd. Samples prepared July 12, 1017, stored at 65° to 75° F. till July 18, and then at 32° F. until August 9

HYDROXIDES OF METALS AND ALLOYS USED	DATES EXAMINED	BUTTER			BUTTERFAT	
		Check	0.4 per cent acid	0.4 per cent NaOH	*0.4 per cent NaOH 1 per cent lactose	0.4 per cent NaOH 1 per cent casein
German silver.....	July 17	Slightly bleached	Normal	Normal	Tallowy and bleached	Slightly tallowy and bleached
	August 9	Very tallowy and bleached	Slightly tallowy, slightly bleached	Tallowy, bleached	Very tallowy, white	Tallowy, bleached
Nickle.....	July 17	Normal	Normal	Slightly metallic	Tallowy and bleached	Normal
	August 9	Normal, slightly bleached	Normal	Normal, slightly bleached	Very tallowy, white	Very slightly tallowy
Tin.....	July 17	Normal	Normal	Normal	Tallowy and bleached	Normal
	August 9	Normal, slightly bleached	Normal	Normal	Very tallowy, white	Very slightly tallowy

* Was bleached and tallowy July 14.

Pure butterfat emulsified with casein and slight excess of alkali showed slight tallowiness and bleaching after five days at room temperature, only in the presence of iron, copper, brass and german silver, respectively. The fat with casein in alkaline solution, without metals, and that with nickle and with tin, respectively was normal. After twenty-three additional days at 32°F. the fat with the copper, brass, and german silver became intensely tallowy and bleached, while with nickle and with tin, it turned slightly tallowy only and without perceptible bleaching.

The butter with a normal content of lactose and without addition of acid, alkalies, or metals remained normal for the entire period of the experiment.

The same butter made acid or alkaline, but without the addition of metals remained normal.

The butter with iron in the absence of added acid or alkali, was tallowy in twenty-eight days, the same butter with acid remained normal and with alkali became distinctly fishy.

The butter with copper, brass and german silver, respectively, with or without alkali, turned white and became very tallowy; with high acid, it became slightly tallowy.

The butter with nickle or tin did not turn tallowy and did not bleach, neither with acid nor with alkali.

The above results, then show that lactose in the presence of an alkali is capable of turning butter and butterfat extremely tallowy and perfectly white. Copper, brass and german silver, in the form of precipitated hydroxides also cause very rapid and intense bleaching and tallowiness in the presence of an alkali in butter. The same metallic hydroxides are capable of producing tallowiness and bleaching in the absence of an alkali, though the action is somewhat slower. In butter with excess acid these metals also produce tallowiness and bleaching, but to a lesser degree. The action of iron in butter, with excess acid or excess alkali is slight and that of tin and nickle is negligible. The presence of casein appears to have no effect with reference to tallowiness.

It is realized that in the case of the samples to which alkali was added the treatment was probably in excess of slight over-

neutralization. It should be remembered, however, that both, the fat and the butter, have a slight acid value so that the actual alkalinity was slight. It may be further noted that this amount of alkalinity is not necessary to produce tallowiness, by referring to experiment table 5, in which the samples with a very nearly neutral reaction and containing lactose turned equally tallowy and to table 8, in which the butterfat actually acid, and containing lactose, turned tallowy.

Experiment with iron and copper, lactose and curd in the presence of alkali and acid in butterfat. In order to secure additional data showing the influence of acidity and alkalinity in the presence of lactose, curd and metals, the foregoing experiment was repeated. The metals used in this test were confined to iron and copper in the form of lactates.

The butterfat was secured from freshly churned unsalted butter, by melting and filtration in the incubator at 45°C. The filtering occupied twenty-nine hours. The fat was washed twice with hot distilled water.

The samples with acid, alkali, lactose and curd, respectively, were prepared by adding the calculated amount of these chemicals in sufficient dilution, so as to make each sample of fat contain from 14 to 15 per cent water.

The iron and copper were added in the form of iron lactate and copper lactate, using three drops of a solution of the metallic lactate to 60 grams of the prepared sample. Exception was made in sample 7 in which case 6 drops of the metallic salt was added.

The curd used was prepared by centrifuging buttermilk, washing the precipitate with distilled water and centrifuging again.

The amount of chemicals used and the amount contained in the finished samples was as follows:

180 grams of prepared samples contained respectively:

10 cc. lactic acid solution, or 0.54 gram or 0.3 per cent lactic acid

6 cc. lactose solution, or 0.63 gram or 0.35 per cent lactose

13 grams curd suspension, or 0.9 gram or 0.5 per cent curd
2 cc. N/2 sodium hydroxide, equivalent to 0.022 per cent NaOH

After the solutions containing the several ingredients had been added to the pure, melted fat, the mixture was cooled by shaking in cold water, until congealed. Three samples (a, b and c) were prepared, of each lot.

The results are assembled in table 5.

The results shown in table 5, correspond with those of the previous experiment. Again the action of the iron was relatively slight, somewhat more pronounced in alkaline reaction than in the presence of acid. The copper again produced intensely tallowy flavor and bleached the fat. This action was strongest in the fat with slight alkaline reaction. The casein failed to produce tallowiness, but yielded a yeasty odor in the presence of acid and a cheesy and putrid odor in the presence of an alkali. The lactose in normal and in acid fat exerted a protective action. Especially was this true in the case of the samples with lactose and acid, which remained perfectly normal, even those containing iron and copper, respectively. In the fat with slight alkaline reaction the lactose intensified the tallowiness. The acid again retarded the development of tallowy flavor while the alkali enhanced it.

The samples also showed marked variations in the consistency of the fat. The fat that was tallowy was extremely granular, that which remained normal and contained no casein was moderately granular and that which contained casein was smooth and soft.

After forty days additional storage at 70° F. these samples were again examined with the following findings:

The samples which had shown tallowiness, or traces of tallowiness, at the time of the first examination, for the most part had developed more intense tallowiness and in many cases were bleached more. The samples with lactose in acid solution (sample 2) remained normal. In samples 3 and 4, containing casein, the slight tallowy flavor was no longer noticeable, prob-

TABLE 5

Showing effect of iron, copper, acid, alkali, lactose and casein respectively on flavor and color, of butterfat, after eight days' storage at a temperature of 70° F.

SAMPLE NUMBERS	SAMPLES CONTAINING, ACID, ALKALI, LACTOSE AND CASEIN	FLAVOR AND COLOR OF BUTTERFAT		
		Samples containing no metals	Samples containing iron or copper	
			Iron	Copper
No. 1 a	0.3 per cent acid	Normal	Very slightly tallowy	Very slightly tallowy
No. 1 b	0.3 per cent acid	Normal	Very slightly tallowy	Very slightly tallowy
No. 1 c	0.3 per cent acid	Normal	Very slightly tallowy	Very slightly tallowy
No. 2 a	0.3 per cent acid	Normal	Normal	Normal
No. 2 b	0.3 per cent acid	Normal	Normal	Normal
No. 2 c	0.35 per cent lactose	Normal	Normal	Normal
No. 3 a	0.3 per cent acid	Yeasty odor	Very slightly tallowy, yeasty	Slightly yeasty odor
No. 3 b	0.3 per cent acid	Yeasty odor	Very slightly tallowy, yeasty	Slightly yeasty odor
No. 3 c	0.5 per cent casein	Yeasty odor	Very slightly tallowy, yeasty	Slightly yeasty odor
No. 4 a	0.3 per cent acid	Yeasty odor	Very slightly tallowy, yeasty	Yeasty odor
No. 4 b	0.35 per cent lactose	Yeasty odor	Very slightly tallowy, yeasty	Yeasty odor
No. 4 c	0.5 per cent casein	Yeasty odor	Very slightly tallowy, yeasty	Yeasty odor
No. 5 a	0.35 per cent lactose	Normal	Normal	Slightly tallowy and bleached
No. 5 b	0.35 per cent lactose	Normal	Normal	Slightly tallowy and bleached
No. 5 c	0.35 per cent lactose	Normal	Normal	Slightly tallowy and bleached
No. 6 a	0.5 per cent casein	Cheesy and putrid	Cheesy and putrid	Cheesy and putrid
No. 6 b	0.5 per cent casein	Cheesy and putrid	Cheesy and putrid	Cheesy and putrid
No. 6 c	0.5 per cent casein	Cheesy and putrid	Cheesy and putrid	Cheesy and putrid

No. 7	a	0.022 per cent NaOH	Normal flavor, bleached	Slightly tallowy, slightly bleached	Very tallowy, bleached
	b		Normal flavor, bleached	Slightly tallowy, slightly bleached	Very tallowy, bleached
	c		Normal flavor, bleached	Slightly tallowy, slightly bleached	Very tallowy, bleached
No. 8	a		Normal flavor	Slightly tallowy, slightly bleached	Very tallowy, white
	b	0.022 per cent NaOH	Normal flavor	Slightly tallowy, slightly bleached	Very tallowy, white
	c	0.35 per cent lactose	Normal flavor	Slightly tallowy, slightly bleached	Very tallowy, white
No. 9	a		Putrid, slightly bleached	Putrid, slightly bleached	Tallowy, white
	b	0.022 per cent NaOH	Putrid, slightly bleached	Putrid, slightly bleached	Tallowy, white
	c	0.5 per cent casein	Putrid, slightly bleached	Putrid, slightly bleached	Tallowy, white
No. 10	a	0.022 per cent NaOH	Stale, slightly bleached	Stale, slightly bleached	Stale, slightly bleached
	b	0.35 per cent lactose	Stale, slightly bleached	Stale, slightly bleached	Stale, slightly bleached
	c	0.5 per cent casein	Stale, slightly bleached	Stale, slightly bleached	Stale, slightly bleached
No. 11	a	Check	Normal	Normal	Tallowy, slightly bleached
	b		Normal	Normal	Tallowy, slightly bleached
	c		Normal	Normal	Tallowy, slightly bleached

ably due to the intense putrid and moldy odor which developed in them and which covered up the original slight tallowy odor. In the case of sample 5, containing lactose, all samples had become intensely tallowy and the samples containing copper in addition to lactose were also white as well as tallowy. In samples of no. 6, containing casein, the cheesy and putrid odors were intensified and also tended toward a sharp moldy odor. Samples 7 and 8 which consisted of butterfat in neutral or very slightly alkaline condition, and butterfat plus lactose in neutral or very slightly alkaline condition, all turned very tallowy and were practically white. Samples 9 and 10 containing casein, became more intensely putrid, except the samples containing copper, especially those of sample 10, which became intensely tallowy and bleached. Samples of no. 11 representing the check, remained normal without metals. Those with iron turned slightly tallowy and those with copper very tallowy and white. All samples which contained casein and which had turned tallowy became brown on the surface, while those containing no casein, and which, in many cases were much more tallowy, turned white on the surface.

Experiment in which the wrapper was treated with chemicals. Previous experiments showed that the bleaching and the development of tallowy flavor and odor commenced on the surface and continued into the body of the butter. They also showed that lactose in alkaline solution greatly accelerated the action. Since parchment paper contains glucose, which has reducing powers, similar to lactose, and since the process of parchmenting may leave an excess of alkali (ammonia) on the wrapper, it was deemed advisable to repeat the previous experiment, but instead of treating the butter with the reagents, under consideration, normal butter was used and the wrapper was treated. The wrappers were treated as follows:

The wrappers were dipped in solutions of the salts of iron and copper. One sheet of each was then dried and these represented the wrappers treated with metals only. The other sheets were dipped in a solution of sodium hydroxide, strong enough to precipitate the metals as hydroxides on the paper. Two of each of these parchments were then dried and these represented the wrap-

pers plus metals in the presence of excess alkali. Other wrappers were treated in a similar manner, but instead of using sodium hydroxide, lime water was used. Still other wrappers were subsequently dipped in a solution of lactic acid of sufficient strength to neutralize the alkali, making the sheets acid. One sheet of each of the above preparations was then washed so as to render them only slightly alkaline or acid, respectively. Normal fresh butter was then wrapped in these parchments and stored at 32° F. and 70° F., respectively. The butter was wrapped June 7, and examined June 15, July 7, and August 9. The results are shown in table 6.

Table 6 shows conclusively the following:

The development of tallowy flavor and bleaching starts more rapidly on the surface of the butter than in its interior, suggesting oxidation with help of atmospheric oxygen.

In the presence of an alkali the butter became tallowy and white much more rapidly, than in the presence of an acid. This again suggests oxidation as the cause, because in alkaline condition, it is greatly hastened. This chemical fact is generally accepted and it has been especially demonstrated in the case of reducing sugars such as lactose, and glucose in the presence of an alkali.

Of the two metallic salts copper again proved to be much more active than iron in the production of tallowiness and bleaching. The action of turning tallowy and bleaching was much more intense at room temperature than at 32° F., showing that there is greater danger of the butter becoming tallowy when exposed to unfavorable temperature conditions.

In a subsequent experiment in which the wrappers were treated with non-metallic salts and sugars in both alkaline and acid condition the butter failed to become tallowy. This indicates that the wrapper is not liable to produce tallowiness unless it, or the butter itself contains metallic salts or metals. The water soluble extracts of the wrappers were found to contain glucose and traces of iron with considerable sulphates. Of recent years parchment wrappers have occasionally contained minute specks of metallic lustre. Microchemical analysis of these specks showed them to

TABLE 6

Showing effect of wrapping butter in parchments which had been dipped in iron salts and copper salts and then in solutions of alkalies and acids, respectively, on the flavor and color of butter. The butter was wrapped June 7, 1917

DATE OF EXAMINATION	TEMPERATURE OF STORAGE	CONTROL SAMPLES NOT TREATED	WRAPPERS DIPPED IN THE FOLLOWING REAGENTS						
			Treated with metal only	Sodium hydroxide		Lactic acid		Lime water	
				Strong solution	Weak solution	Strong	Weak	Strong	Weak
Parchment treated with iron salt									
June 15	70	Normal	Slightly tallowy	Slightly tallowy	Normal	Normal	Normal	Tallowy	Normal
July 7	70	Normal	Slightly tallowy	Tallowy	Tallowy	Normal	Normal	Tallowy	Tallowy
July 7	32	Normal	Normal	Slightly tallowy	Normal	Normal	Normal	Normal	Normal
August 9	32	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Parchment treated with copper salt									
June 15	70	Normal	Tallowy	Very tallowy	Very tallowy	Normal	Slightly tallowy	Normal	Slightly tallowy
July 7	70	Normal	Tallowy	Very tallowy	Very tallowy	Slightly tallowy	Tallowy	Tallowy	Tallowy
July 7	32	Normal	Tallowy	Very tallowy	Very tallowy	Normal	Normal	Very tallowy	Slightly tallowy
August 9	32	Normal	Tallowy and slightly bleached	Very tallowy	Very tallowy	Normal	Normal	Very tallowy	Tallowy

be or to contain copper. When wrappers containing such specks are used, a green coloration gradually appears on the butter and on parchment where these specks are located. The presence of these copper specks may under favorable conditions, start sufficient oxidation to turn the butter tallowy and to bleach it. They exert a catalytic action which is progressive and may cause the entire package to become tallowy.

FAT CONSTANTS IN TALLOWY BUTTER AND IN THE CONTROL SAMPLES

The samples of tallowy butter of the previous experiments were mixed and the control samples of the same experiments which did not turn tallowy were mixed. Each of these mixed lots was analyzed for fat constants separately, the results are shown in table 7.

TABLE 7

Showing fat constants in mixed samples of tallowy butter, and in samples of the same butter which did not turn tallowy

FAT FROM TALLOWY BUTTER AND FROM SAME BUTTER NOT TALLOWY	IODINE NUMBER	MELTING POINT	SAPONIFICATION VALUE	TRUE ACETYL VALUE	ACIDS AS BUTYRIC	MELTING POINT INSOLUBLE ACIDS
		°C.				°C.
Tallowy	38.12	34.6	225.33	8.08	6.72	40.35
Check	39.23	32.5	225.30	5.89	6.60	40.04
Difference	1.09	2.1	0.03	2.19	0.12	0.30

The above figures show a decrease of 1.09 points in the iodine number of the tallowy fat and an increase in its melting point of 2.1°C. The decrease in the iodine number indicates at least some absorption of oxygen. The increase of the melting point of the total fat of the tallowy butter suggests that acids of higher melting point are formed. Table 7 further shows that there was no appreciable change in the saponification value of the tallowy fat. However, these saponification values undoubtedly have been affected by the alkali present in the mixed tallowy butter, which obviously would saponify a portion of the fatty acid and be washed out. The absence of an increase of the volatile acids, as expressed by the Reichert Meissl Number, indicates that there

was no breaking down of the fatty acids into acids of lower molecular weight. However, the Reichert Meissl number might have been affected in a similar manner as the saponification value in the presence of an alkali.

Since the conclusiveness of the data given in table 7, was somewhat marred by the uncertainty of the amount of alkali present in the fat of the mixed tallowy butter, the determination of the fat constants was repeated and in this case with butterfat to which the same amount of alkali (1 cc. N/2) had been added to each 100 grams of butterfat at the beginning of the experiment. These results are shown in table 8.

TABLE 8

Showing fat constants in fresh and tallowy butterfat

	IODINE NUMBER	SAPONIFICATION VALUE	ACID VALUE	MELTING POINT	FLAVOR
1. Check, pure fat	42.855	222.0	0.6	32.9	Fresh
2. 1 cc. N/2 NaOH in sunlight	42.20	222.5	0.89	33.5	Tallowy
. 1 cc. 3 N/OH, 0.5 cc. copper lactose, sunlight	41.755	221.6	0.28	34.6	Very tallowy
4. 1 cc. N/2 NaOH, in dark	42.405	222.9	0.33	33.5	Turned tallowy while filtering fat for determination
5. 1 cc. N/2 NaOH, 1 per cent lactose, in dark	41.91	222.4	0.66	34.3	Very tallowy
6. 1 cc. N/2 NaOH, 1.5 cc. copper lactose, in dark	41.79	222.0	0.33	34.5	Very tallowy

In the above experiment pure butterfat was used in lots of 85 grams for each sample. To this fat was added 15 cc. of a solution containing 1 cc. N/2 sodium hydroxide in water, which corresponds to 0.02 of 1 per cent of sodium hydroxide in 100 grams of the mixture. To the solution used in samples 3 and 6, 0.5 cc. of dilute copper lactate solution was added. To the solution used in sample 5, 1 gram of lactose was added. Sample 1 was kept in the dark at 32° F. Samples 2 and 3 were kept exposed to light at 70° F. and samples 4, 5 and 6 were kept in the dark at

70° F. All samples were tightly sealed in glass-stoppered bottles. At the end of thirteen days they were examined for odor and fat constants.

As expected, all samples except the check and sample 4 which contained neither lactose nor copper and was kept in the dark, turned conpletely tallowy. Sample 4 turned tallowy only while being filtered for determination of fat constants.

The results in table 8 again show a decrease in the iodine number in the case of the tallowy fat. The decrease was greatest (1.1 points) in the fat that was most tallowy. There was also a marked increase in the melting point of the tallowy fat, similar to that shown in table 7. The evidence brought out in these two tables leaves no doubt that there is a slight absorption of oxygen by the fat or fatty acids. However, it does not necessarily follow that it is merely the absorption of oxygen by the oleic acid which causes the development of the tallowy flavor and odor. If oleic acid, which has been exposed to the atmosphere at about 45° C. in a thin layer and which, in this manner has suffered a reduction in the iodine number, from 87 to 79, is added to butter, the butter does not show a tallowy taste or odor. But it was observed that butter containing free aleic acid and which had been exposed to the air, became tallowy very rapidly. This suggests that tallowiness is not the direct result of oxidized oleic acid, but rather that it is caused by products formed in the butter during the absorption of oxygen by the oleic acid, such as glycollic acid ester of oleic acid, the glycollic acid coming from the oxidation of the glycerol. These possible by-products are not formed when the oleic acid is oxidized separately from the butter.

Bearing in mind that the presence of copper, or lactose, the latter only in alkaline solution, produces tallowy flavor very intensely, even in the dark, and at 32° F. and without excessive exposure to air, invites a study of the probable products of these agents. McKenzie (11) states that glycollic acid is one of the chief products of the action of copper hydrate in alkaline solution on lactose. Neff (12) shows that glycollic acid is formed from the sugars with silver oxide. McLeod (13) found that the ac-

tion of copper acetate on glucose, levulose and galactose produced considerable quantities (3 per cent) of glycollic acid. Furthermore, one method of preparation of glycollic acid is that of oxidation of glycerol in a dilute alkaline solution with silver oxide (14).

It is interesting also to note the fact that glycollic acid is naturally found in the fat of sheeps' wool (15) showing the probable close relation between glycollic acid and tallowy odor.

In the presence of these facts it seemed logical to determine the effect of glycollic acid on the flavor and odor of butterfat. The addition to butterfat, of free glycollic acid did not produce tallowy flavor. But the addition of the glycollic acid esters of the fatty acids of butter when warmed with butterfat, produced a tallowy flavor. This was especially the case of the glycollicacid ester made with oleic acid. This flavor was produced strictly in the absence of air, and check samples in which oleic acid alone was added showed no tallowy flavor. Although these results are not borne out by any noticeable increase in the saponification value, it may be readily seen that the glycollic acid ester found, which is necessary to produce tallowiness, may be of such small amount, as to cause no appreciable change in this fat constant. That an exceedingly small amount of glycollic acid ester is sufficient to produce tallowiness is shown by the fact that the addition of 0.25 per cent of this reagent to butterfat, produced a distinctly tallowy odor and flavor. The oleic acid and the oleic acid esters prepared from monochlor acetic acid and silver oleate, which were used had the following constants.

TABLE 9

Showing constants of oleic acid and oleic acid esters used

REAGENTS	IODINE NUMBER	SAPONIFICATION VALUE	ACID VALUE	MELTING POINT	REMARKS
Oleic acid ester of glycollic acid.....	85.13	199.0	189.8	18.6	Calculated ester 5.85 per cent
Oleic acid unexposed.....	86.715	194.6	193.1	16.9	
Oleic acid exposed twenty-four hours	78.82	192.5	188.4	17.7	

RESUMÉ OF CHEMICAL REACTIONS RELATED TO TALLOWY BUTTER

From the foregoing findings we must conclude that the butter defect known as tallowiness is the result of an oxidation process. If this oxidation takes place in the butterfat alone, it is suggested that the compound, which it is necessary to link up with the fatty acids, in order to make butter tallowy, is derived from free glycerol produced by a slight or partial hydrolysis of the fat. This compound appears to be glycollic acid.

It has been conclusively shown that lactose in a neutral or slightly alkaline medium very greatly intensifies the results of oxidation. This is due to the fact that simultaneously with the fat, the lactose is also subject to mild oxidation, producing an excess of glycollic acid, while in the case of pure fat alone, the formation of glycollic acid from the small amount of glycerol alone is much slower. The conditions and agencies favoring oxidation may be conveniently grouped as follows:

1. Exposure of butter or butterfat to air. The oxidation here is intensified in the presence of light or at a high temperature, or both.

2. The presence in butter or butterfat of oxidizing agents such as metals or metallic salts. These act as oxygen carriers or catalizing agents. From our knowledge of the chemistry of the metals, as well as of the experimental results already obtained, we would expect, that copper salts and alloys of copper, such as brass and german silver, are the most active metals and alloys that enter into the problem in commercial buttermaking. Iron oxide has a specific catalytic action which aids this oxidation process, while in the case of iron bases and salts this action is relatively slight.

3. The presence of an unnatural alkaline condition of the butter or cream from which the butter is made which accelerated any oxidizing action by making the compounds oxidized more susceptible to oxidation. This unnatural alkaline condition may be due to an over neutralization of the cream or other factors which expose butter to alkaline conditions.

APPLICATION OF THESE FINDINGS TO COMMERCIAL CONDITIONS

Air, light and heat. As before stated, these three factors readily bring about oxidation of the fat in butter and butter so exposed is prone to develop a tallowy flavor. This fact is well known to the layman. Talloviness caused through these channels is comparatively rare, because the commercial butter is guarded against these agents. The wrappers and cartons of print butter, and the liners and paraffined tubs and cubes of bulk butter protect the butter against excessive exposure to air and light. While the butter remains in the creamery, it is usually kept at a temperature far below that at which heat alone is capable of producing tallowiness. Butter intended for immediate consumption (within one to three weeks) does not become tallowy even at ordinary ice box temperature, such as it is exposed to in the store and in the home, unless it contains other agents that cause tallowiness. The bulk of the butter going to the tropics is packed in hermetically sealed cans, which greatly minimizes the action of the heat, owing to the partial exclusion of the air and the entire absence of the light. Butter intended for storage purposes does not develop tallowiness because the temperature of commercial butter storage sufficiently retards the action of air and light. Although under present commercial conditions of manufacture and handling of butter, air, light and heat are improbable causes of tallowiness, their importance should not be ignored and every effort should be made to protect the butter from these agents.

Metals and metallic salts. It has been shown that metals and alloys, such as iron, copper, brass and german silver, and their salts, are capable of turning butter tallowy in a short time. Most of the equipment used in the handling of cream and manufacture of butter is constructed of iron or copper, usually originally coated with tin. When this tin coating wears off, as it always does to a greater or less extent, the iron or copper becomes exposed and often the exposed iron is permitted to rust and the exposed copper allowed to become coated with verdigris. In this condition these metals are the most active, considerable portions

being dissolved by the acid in the cream and thus not only act in the cream, but also find their way into the butter, jeopardizing its quality and inviting the development of tallowy flavor.

This danger can best be minimized, if not entirely avoided, by handling the cream in non-rusty cans and preventing the cans from rusting by systematic and thorough washing, rinsing, steaming and drying; keeping the vats, coils, pasteuriziers, forewarmers, pumps, pipes, and conduits well tinned, thoroughly cleaning and drying them after each day's use and flushing them with hot water each morning before circulating the cream; preventing the packing and printing equipment from rusting; and using wrappers and liners only which are free from metals.

Lactose in butter. Sugar in butter, such as lactose, and glucose, under certain conditions, as explained in the succeeding paragraph, give rise to tallowy butter, but when butter is made under proper conditions and containing a normal amount of acid, the presence of lactose has no injurious effect on its flavor and does not constitute in itself, a cause of tallowy butter. In fact, the addition of lactose to butter, when in a normal acid condition, may have a slight preservative effect.

Overneutralization. Overneutralization with any alkali very greatly intensifies the oxidizing action of all the foregoing agents and hastens the development of tallowiness. This can only be permanently prevented by the careful standardization of the entire operation of neutralization, including the testing of cream for acid, the preparation of the neutralizer and the addition of it to the cream. The butter should further be guarded against direct contact with alkalies, by the complete removal from churns, cubes and other packing equipment, of all traces of alkaline wash water and the use of wrapping paper which is free from alkali such as ammonia, which is used to neutralize the sulphuric acid employed in the parchmentizing process.

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THE RELATION OF OIDIUM LACTIS AND PENICILLIUM TO THE KEEPING QUALITIES OF BUTTER

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The factors involved in the deterioration of butter have received considerable study in recent years. Attention has been directed especially towards certain abnormal flavors and attempts made to connect them with the activity of particular microorganisms. Most of the work along these lines, with the exception of the extensive work of Rogers, has been in the nature of a study of the butter itself. The writers are of the opinion that a study of the cream is more likely to yield results, when the action of microorganism is suspected, than is a study of the butter.

The high acidity, the salt content and the limited amount of air make the conditions in butter unfavorable for the growth of the large majority of organisms. The changes that take place in the butter constituents so far as related to microorganisms would presumably be brought about by the activities of enzymes the action of which would not be stopped by these conditions. The cream is a far better media than butter for the growth of organisms and the enzymes produced would necessarily be carried into the butter where the effects might not be apparent until some time after the butter was made. By the time the butter has deteriorated to an appreciable extent, the organisms producing the enzymes may have all disappeared. The little success which has so far been attained in determining the causes of specific defects in butter flavor may be partially at least explained on this basis.

RELATION OF MOLD TO DETERIORATION OF BUTTER

Rather extensive studies have been made of molds and Oidium lactis in connection with dairy products especially the ripening of soft cheeses. Several investigators including, Gripenberg (1),

O'Callaghan (2) and Jensen (3) have also concluded that molds and Oidium lactis are of importance in relation to the keeping qualities of butter. The study of this problem has, however, been confined to the butter and no attention given to the results of mold growth in cream before churning. The frequent occurrence of mold in butter packages on the market, especially tubs, is responsible for a wide interest in the relation of mold in this form to the keeping quality of butter.

Thom in a recent paper states that molds do not grow readily upon butter. The conditions necessary for its growth are a high humidity of the surrounding atmosphere, a high moisture content, and low salt content of the butter. Experiments by the present authors corroborated these results.

OBJECT OF EXPERIMENTAL WORK

The primary object of the experiments reported in this paper was to determine the relation of *Oidium lactis* and a mold of the Penicillium group to the keeping qualities of butter, especially when these organisms had developed in the cream before churning.

Oidium lactis was selected as one of the organisms on account of its wide distribution in dairy products and its well known relation to certain dairy products. A number of molds of the penicillium growth the spores of which were found present in butter were studied and a type identified as *P. Chrysogenum* selected for the experiments.

Description of butter. As it is practically impossible to find terms which will convey the idea of the precise flavor of butter it was thought advisable to indicate the flavor of butter examined in these experiments on a percentage basis. Where check samples of butter were compared with the experimental the flavor of the check sample was given a value of 1.00, and variations from the check sample were indicated by decimal parts of 1.00 which shows the extent the butter in question varied from the check according to the judgment of those making the examination.

Butter given a flavor of 1.00 was first class butter while that

ranging between 0.90 and 0.99 would be considered second grade, that graded from 0.75 to 0.89 rather poor, though it could possibly be sold on the market, and that graded 0.70 or below was too inferior for human consumption. The entire series of experiments included 58 separate churnings and observations on 658 samples of butter.

RESULTS OF OIDIUM LACTIS AND P. CHRYSOGENUM UPON BUTTER

Only a portion of the data taken is given but the results were consistent and conclusive. Pure cultures of the molds grown upon samples of sweet cream were found to be detrimental to the quality of the cream as judged from the standpoint of the practical buttermaker. However, when the same molds were grown upon sour cream no ill effects whatever upon the quality of the cream could be observed. The resulting butter, however, went off flavor very quickly in either case as is shown in table 1.

TABLE 1

The growth of molds upon sweet and sour cream and the effect upon the resulting butter

CONDITION OF CREAM	INOCULATION	QUALITY OF BUTTER			
		Fresh	30 days	60 days	90 days
Sweet	Penicillium	1.00	0.90	0.85	0.70
Sour	Penicillium	1.00	0.75	0.60	0.50
Sweet	Oidium	1.00	0.85	0.75	0.60
Sour	Oidium	1.00	0.70	0.65	0.55
Sweet	Penicillium and Oidium	1.00	0.70	0.60	0.50
Sour	Penicillium and Oidium	1.00	0.80	0.55	0.45
Sweet	None (check)	1.00	1.00	0.95	0.75
Sour	None (check)	1.00	1.00	1.00	1.00

The above data shows that when the molds made growth upon either sweet or sour cream the resulting butter went off in flavor very rapidly. It is also interesting to note that, though mold growth upon sour cream did not seem to affect the quality of

that cream as judged by taste the resulting butter had poorer keeping qualities than the butter made from the sweet cream on which the molds had previously been grown. The butter made from cream on which the two molds used in the experiments had been allowed to grow together in every case showed a poorer

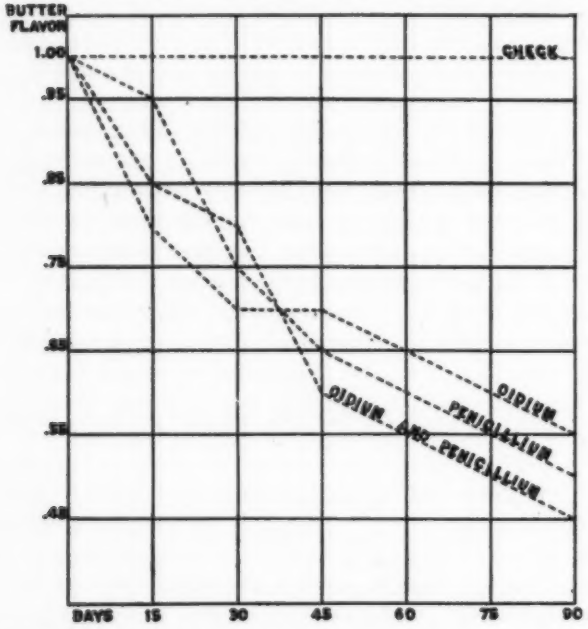

FIG. 1. THE RELATION OF PENICILLIUM AND OIDIUM GROWTH UPON SOUR CREAM TO THE KEEPING QUALITIES OF BUTTER

The growth of these organisms upon cream results in very rapid deterioration of the butter as the figure shows. The check sample, free from mold growth, showed but little deterioration in three months while the butter from the cream in which the molds had grown freely was unfit for human food.

keeping quality than the butter which was made from cream on which only one of the molds had grown. Figure 1 shows graphically the rate of deterioration of the butter made from sour cream in which Penicillium and Oidium had been allowed to grow.

The pronounced effect of mold growth in cream upon the keeping quality of the butter may be explained in two ways: The first is that the mold spores which are produced by the growing molds are carried into the butter and there grow and bring about the decomposition of the butter constituents which results in butter of very poor keeping qualities. The second possible explanation is that the molds while growing upon the cream secrete enzymes which are carried over into the butter at time of making and gradually bring about a decomposition of the butter constituents. Experimental work was conducted to determine which of these is the true explanation. A large number of cream samples were inoculated with the *Oidium lactis* and *P. Chrysogenum* and the butter churned after the molds had developed to the point of forming spores and placed in 100 cc. Erlenmeyer flasks. The flasks were placed at ice box temperature in a receptable protected from outside contamination and in no case did the mold appear upon the butter, though the cream from which this butter was made must have contained enormous numbers of mold spores. Other trials were made by working large numbers of mold spores directly into freshly made butter but no growth of mold appeared on the surface.

The number of mold spores in a gram was also determined by the plate method for several samples of fresh butter, some of which were stored in a dry and others in a humid atmosphere. In every case there was an actual decrease in the number of mold spores contained in the butter at the end of thirty days. These results seemed to show conclusively that molds are not able to germinate or make growth within butter.

Another series of experiments was conducted to determine if the enzymes produced by the molds while growing upon cream were the cause of the rapid deterioration of the butter made from such cream.

Seven gallon lots of cream were pasteurized and a 5 per cent starter of *B. lactis acidi* added to each. Two were inoculated with *Oidium lactis*, two with *P. Chrysogenum*, two with both organisms, and one was kept for a check. All were allowed to stand at 70° F. for eight days during which an abundant growth was made by

both molds. All were then pasteurized at 145° F. for twenty minutes and cooled to the proper temperature and churned.

Another set of seven was treated in exactly the same manner except the cream samples were pasteurized at a temperature of

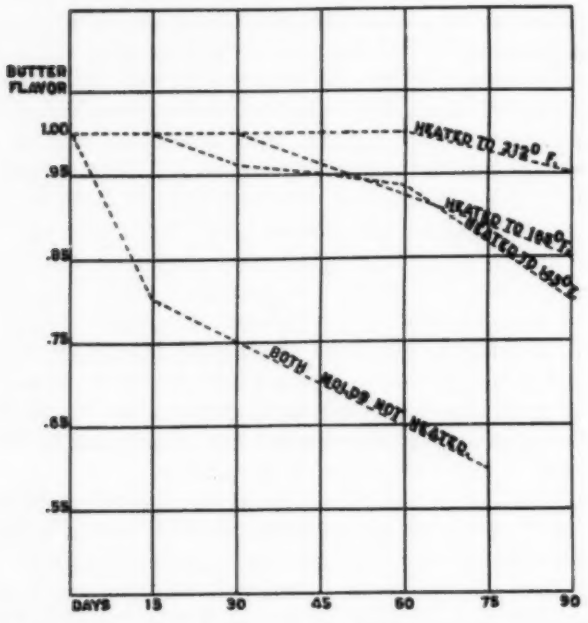

FIG. 2. THE RESULTS OF HEATING CREAM IN WHICH OIDIUM AND PENCILLIUM HAD GROWN, TO A TEMPERATURE OF 165°F.

These data show that a temperature of 165°F. for five minutes is not sufficient to entirely destroy the action of the enzymes produced in the cream by the molds. In each case the results were the most marked where both organisms had grown together.

165° F. for five minutes. A third set was also a duplicate of the first except the cream was heated to 212° F.

A fourth set of five lots of cream was prepared in a similar manner and four of them inoculated with both molds. One was heated to 145° F., a second to 165° and the third to 212°. One

check contained the mold growth but was not heated and one check was not inoculated.

The results of these experiments showed that heating to 145° F. improved the keeping qualities of the butter over that of the check lot not heated but did not prevent it from going off rapidly

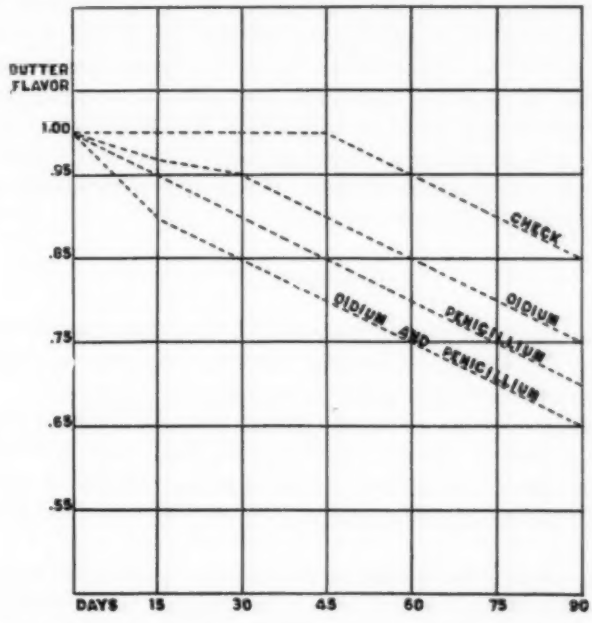

FIG. 3. THE RESULTS OF DIFFERENT TEMPERATURES UPON THE KEEPING QUALITIES OF THE BUTTER

This figure shows the results on the keeping quality of butter of heating cream on which both molds had grown. The keeping quality was greatly improved by pasteurizing at a temperature of 145°F., was still better at 165°, and the least deterioration occurred in that heated to 212°.

in flavor due to the mold growth. Pasteurizing at 165° was more effective than at 145°. At 212° the deterioration due to the presence of the mold seems to be entirely removed. The results of a temperature of 165° F. is shown in figure 2 and a comparison of results at the three temperatures in figure 3.

It will be noted from figure 3 that the butter made from that cream on which the molds were grown and which received no pasteurization went off in flavor very rapidly. By the end of forty-five days the butter from this cream was absolutely unfit for human consumption. These results must be interpreted to mean that the decidedly better keeping quality of the butter from the pasteurized cream was due to the destruction of the enzymes formed in the cream by the molds. It also suggests that the well known beneficial results of pasteurization upon the keeping qualities of butter as practiced in a commercial way is probably to be attributed, to a considerable extent at least, to the destruction of the enzymes produced by various organisms in the cream and milk from which the butter was made.

CONCLUSION

Molds do not grow readily upon butter, but their growth is influenced by the amount of protein, salt and moisture, the butter contains and the moisture of the surrounding atmosphere.

The quality of cream as usually judged by taste is influenced to a marked degree by the growth of *Oidium lactis* and *P. Chrysogenus* when the cream is sweet but no objectionable flavor can be detected in the cream as a result of mold growth when the cream is sour.

The growth of *Oidium lactis* or *Penicillium* upon cream exerts a decidedly detrimental effect upon the keeping qualities of the butter.

Mold spores do not germinate or make growth in butter. The growth of mold on butter is the result of a contamination from the outside.

Pasteurization at ordinary temperatures greatly improves the keeping qualities of butter made from cream upon which molds have made growth but it does not entirely check the action of the enzymes which they produce. This action may be checked entirely by heating to a sufficiently high temperature but this point is beyond the limit of practicability for commercial use.

The abnormal flavors which develop in butter, due to mold

growth on the cream, are caused by enzymes which are secreted by the mold in the cream.

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RULES AND REGULATIONS FOR CLEAN AND SAFE MILK SUPPLY[1]

ERNEST KELLY, JOHN B. NEWMAN AND GEORGE S. HINE

Your committee realizes that the task set before it is one of the most important, as well as one of the most difficult, that could have been selected. It is important because upon it depends the protection of the consumer against impure milk, the safeguarding of the dairyman against unreasonable requirements, and the unifying of inspection systems; and it is difficult, because out of a diverse and multitudinous mass of regulations must be selected the clear, simple directions which will make possible the accomplishment of the desired results.

Much of the dissatisfaction with milk inspection in the past has been due to the fact that local authorities have had enacted into law their personal opinions which were often based on insufficient experience. Such a course was natural; bad conditions had to be dealt with; action was necessary; and officials moved along lines that seemed best to them. Many health officials have not the facilities for carrying on research work and must depend to a great extent upon the findings of others. Slowly but surely investigating bodies have been at work on the problem of dairy sanitation and we now understand more fully some of the basic principles.

Your committee feels some trepidation in dealing with this subject, because we realize that many men have many minds; and it is almost impossible to draw conclusions which will satisfy everyone and which will not be liable to misinterpretation. In outlining the following regulations, we do so realizing that we have not perhaps incorporated in them all that should be incorporated; but we do believe that they constitute the fundamental principles of clean and safe milk. We further believe that if these rules are carried out our cities will have all reasonable as-

[1] A report of the International Dairy and Milk Inspectors' Committee on Rules and Regulations Necessary for Securing a Clean and Safe Milk Supply.

surance of a pure milk supply. We have not attempted to deal with chemical standards or other considerations more or less of a local problem.

RULES FOR PRODUCTION

1. Every dairy producing market milk should be licensed by the city or State so that a complete record may be kept.

2. Cattle should be healthy as determined by the tuberculin test and a physical examination by a competent veterinarian. They should be tested at least once a year and where reactors are found they should be removed and a retest conducted within six months. If the milk is to be properly pasteurized, the physical examination may suffice, but the committee wishes to affirm its belief in the economic and sanitary importance of the tuberculin test. Milk should be unsalable from cows within fifteen days before calving and as long thereafter as the milk is abnormal.

3. All persons engaged in the production of milk should be free from communicable disease and from contact with any such disease. Medical examination of employees is advised where feasible.

4. Every operator of a dairy farm should, within twenty-four hours, notify the health department having jurisdiction over his milk, of the presence of any communicable disease on his farm or among the milk handlers.

5. The water supply on premises where milk is produced should be abundant and protected from contamination. It should be free from any disease-producing organisms.

6. Privies on dairy farms should be fly-proof, and provided with a water-tight receptacle for the excreta. The excreta should be removed frequently and buried at least two feet deep, where it cannot contaminate the water supply.

7. Cows should be clean. They should be free from accumulations of dirt and their udders and flanks should be wiped with a clean, damp cloth just previous to milking.

8. Milking should be done with clean, dry hands or with a properly sterilized mechanical milker. Milkers should milk in clean clothing.

9. Some type of small-top milking pail should be used.

10. Milk should be removed as soon as drawn, to a clean place, strained through a new cotton or other clean, efficient strainer, and be cooled within one hour to 50° F. or less. It should be kept covered and be held below 50° F. at all times.

11. All utensils which come in contact with milk should be thoroughly washed and sterilized for at least five minutes with steam or boiling water. They should be kept inverted and protected from contamination until used.

RULES FOR TRANSPORTATION

During transportation from farm to city, milk should be kept free from contamination and should be held at or below 50° F.

RULES FOR HANDLING AND DELIVERY

1. All persons engaged in the sale of milk should be licensed by the State or city in which they conduct their business.

2. All persons engaged in the handling or delivery of milk should be free from communicable diseases and from contact with such diseases. The operator of any milk plant should immediately advise the health department of the presence of any such diseases among his employees or in their homes.

3. The water supply of all establishments where milk is handled should be pure and free from disease-producing organisms.

4. Proper toilet facilities should be provided for all employees, together with wash bowl, soap and towel for the cleansing of hands.

5. Where pasteurization is performed, a temperature of approximately 145, and never less than 142° F. should be maintained for at least thirty minutes.

6. All machinery, cans, bottles, etc., with which milk comes in contact should be thoroughly washed and sterilized with steam or boiling water; and they should be protected from contamination until used.

7. At all times, except during pasteurization, milk should be held at or below 50° F. until delivered to the consumer.

8. Milk should be delivered to the consumer only in bottles or sealed cans.

RECOMMENDATIONS

Production

Your committee wishes to emphatically state that many things are desirable in the production and handling of milk that may not greatly affect the bacteria count. Common decency, economy and the esthetic effect on the buyer demand close attention on the part of the dairyman to many details regarding which it may not be advisable to legislate. Such things as clean stables, whitewashing, bedding, etc., come in this category. The comfort and health of the herd depend to a certain extent on clean, light, airy quarters and abundant, wholesome food and water.

In view of these facts your committee considers that a system is advisable, which combines sanitary inspections and laboratory examinations. Practical experience has shown that the dairy score card offers the most useful medium for sanitary inspection, because it serves as a guide to both inspector and inspected. We therefore urge the continued use of a uniform standard score card based on the fundamentals of dairy sanitation.

TRANSPORTATION

It is recommended that covered platforms be maintained for the protection of milk awaiting shipment. Milk should be shipped in refrigerator cars, or in special or jacketed cans which will maintain low temperatures. Cans of milk should be sealed at the farm to prevent tampering en route.

Handling and delivery

Considerations regarding general cleanliness apply in the city as well as at the farm.

Your committee is of the opinion that the proper pasteurization of milk provides an additional safeguard without any ap-

preciable disadvantages and is necessary with all milk except certain special classes; and it is probably advisable with those. Automatic temperature controls and recording devices are recommended.

We recommend that no dipped milk be sold either from stores or wagons. We further recommend that milk bottles be capped by machine and that the mouths of the bottles be protected by a covering.

Repasteurization of milk is undesirable.

Conclusion

Your committee wishes to state that it has had no intention to cover the whole broad field of milk control, but simply to define the necessary regulations from a sanitary standpoint. Following such rules will eliminate many needless burdens on the dairymen. At the same time those things which have a definite effect on milk quality must be maintained even though they may result in additional costs which must be passed on to the consumer as his share in a national health insurance.

THE STANDARDIZATION OF MARKET MILK

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The standardization of market milk is attracting much attention at the present time. Very little information is available in regard to it. This article has for its purpose a discussion of this subject with a view to furnishing some desirable facts. The treatment is intended to be suggestive rather than exhaustive.

What do we mean by the standardization of milk? Or, perhaps, it is better to put the question in this form: "What do we mean by standardized milk?" We get no help from the dictionary. What kind of a standard have we in mind? Is it a sanitary standard, covering the number of bacteria in milk, the amount of dirt, acidity, etc.? Or is it a standard of composition based on fat and solids? Or is it something else?

It becomes obvious at once that the expression "standardized milk" does not carry its meaning on its face. As a matter of fact there is no generally recognized, authentic definition. Our chief interest in this connection is some sort of a reasonable statement which applies to conditions in New York State and which can be utilized as a basis for our discussion.

Another expression is in common use, synonymous with standardized milk, and that is "adjusted milk." It is therefore desirable to incorporate these two terms in our definition.

The following statement is offered as a definition of the kind of milk that forms the subject of our discussion:

Standardized milk or adjusted milk is milk in which the original fat content has been changed, and also the ratio of fat to the other milk solids, by the removal of milk-fat, or by the addition of skim-milk, or by the addition of cream.

Of course, when it comes to legalizing the sale of standardized or adjusted milk, then we have to consider the application of

this definition under conditions of specific limitations and regulations, as will be pointed out later in some detail.

We will now consider the subject in the following relations:

1. Effect of standardizing or adjusting milk upon the composition of normal milk.
2. Relations of standardized or adjusted milk to producers, distributors and consumers.
3. Advantages and objections.
4. Legal regulations relating to the production and sale of standardized or adjusted milk.

1. EFFECT OF STANDARDIZING MILK UPON ITS COMPOSITION

The fat content of milk can be changed, with a change of ratio of fat to other solids, either by decreasing or increasing the percentage of milk-fat. In either case we have a standardized or adjusted product.

We will first consider the case in which we have a reduction of milk-fat. The percentage of fat in milk can be decreased, with change of ratio of fat to other solids, either by removal of fat or by addition of skim-milk. This is ordinarily accomplished in practice by separating a portion of the milk and then adding the skim-milk thus obtained to the remaining whole milk. Just how the reduction of the percentage of fat is accomplished is, however, immaterial for our present purpose. What we want to know now is the effect of such reduction upon the composition of normal milk.

When we remove cream from milk, the chief solid constituent that we take out is milk-fat. It is true that we also take out small amounts of other solids, which we commonly speak of as solids-not-fat, these including sugar, casein, albumin and salts of milk. But, for all practical purposes, in studying the effect of removal of fat on composition of milk, we are justified in saying that only fat is removed. Therefore, when we take cream from milk we reduce the percentage of fat in the milk but not appreciably the percentage of the other solids, the solids-not-fat.

We can readily make these statements clear by a few illustra-

tions. The figures which we give are sufficiently accurate for our purpose and for all practical purposes.

We will start with normal milk containing 4 per cent of milk-fat and 9.1 per cent of solids-not-fat. When we take 100 pounds of such milk and remove 1 per cent of fat, that is, 1 pound of fat, it is obvious that we have 3 pounds, or about 3 per cent of fat left in the milk. How about the solids-not-fat? We have essentially the same amount as in the normal milk before removal of fat, that is, about 9.1 per cent. We can bring out somewhat more clearly what happens by comparing this standardized or adjusted milk, made to contain 3 per cent of fat, with the composition of normal milk, containing 3 and 4 per cent of fat.

	FAT	SOLIDS-NOT-FAT	RATIO OF FAT TO SOLIDS-NOT-FAT
	per cent	*per cent*	
Normal milk containing	3	8.60	1:2.87
Normal milk containing	4	9.10	1:2.27
Adjusted milk containing	3	9.10	1:3.03

These figures show clearly that in milk standardized or adjusted to contain 3 per cent of fat, made from normal milk containing 4 per cent of fat, we have the same amount of fat as in normal milk containing 3 per cent of fat, but we have the 9.1 per cent of solids-not-fat contained in normal milk carrying 4 per cent of fat. Normal milk containing 3 per cent of fat contains an average of about 8.60 per cent of solids-not-fat, while standardized or adjusted milk containing 3 per cent of fat and made from normal milk containing 4 per cent of fat, contains 9.1 per cent of solids-not-fat. In other words, such a standardized or adjusted 3 per cent fat milk contains per 100 pounds one-half pound more of solids-not-fat than does normal 3 per cent fat milk.

In the last column of the table above, we have the amount of solids-not-fat for each pound of fat in milk in the different milks. It is obvious that the removal of fat changes very noticeably the ratio or proportion of fat to solids-not-fat, raising it from 2.27 in normal 4 per cent fat milk to 3.03 in the adjusted or standardized 3 per cent fat milk.

Similar results, only more striking, are shown when normal milk containing 5 per cent of fat is adjusted or standardized to contain 3 per cent of fat. We have the results shown by the following figures:

	FAT	SOLIDS-NOT-FAT	RATIO OF FAT TO SOLIDS-NOT-FAT
	per cent	*per cent*	
Normal milk containing	3	8.60	1:2.27
Normal milk containing	5	9.50	1:1.90
Standardized milk containing	3	9.50	1:3.17

In this case the standardized or adjusted 3 per cent fat milk, made from normal 5 per cent fat milk, contains the solids-not-fat belonging to normal 5 per cent fat milk, that is, about 0.9 pound more per 100 pounds than in normal 3 per cent fat milk. The ratio of fat to solids-not-fat in the adjusted milk is 1:3.17, which is much higher than in normal 3 per cent fat milk.

We will give one more illustration, showing the results of adjusting normal 5 per cent fat milk to standardized milk containing 4 per cent of fat.

	FAT	SOLIDS-NOT-FAT	RATIO OF FAT TO SOLIDS-NOT-FAT
	per cent	*per cent*	
Normal milk containing	4	9.10	1:2.27
Normal milk containing	5	9.50	1:1.90
Adjusted milk containing	4	9.50	1:2.47

In this case the adjusted milk contains 4 per cent of fat but it contains the amount of solids-not-fat belonging to normal milk containing 5 per cent of fat.

The figures furnished by the three preceding illustrations all go to show that *when the percentage of fat in milk is reduced, the resulting standardized or adjusted milk contains the percentage of solids-not-fat in the original normal milk.* Therefore, the food value of the adjusted milk is somewhat greater than in case of the normal milk containing the same percentage of fat as that to which the richer milk has been reduced. Standardized or

adjusted milk containing 3 per cent of fat and made from richer milk is richer in solids-not-fat than normal milk containing 3 per cent of fat. Standardized or adjusted milk containing 4 per cent of fat and made from richer milk is richer in solids-not-fat than is normal milk containing 4 per cent of fat.

Next, let us see what happens to the composition of milk when it is standardized or adjusted by the reverse process, that is, by the addition, instead of removal, of cream. Briefly answered, such standardized milk contains obviously more fat than the original milk, but it contains essentially the same percentage of solids-not-fat as the original milk. Such adjusted or standardized milk contains a smaller percentage of solids-not-fat than does normal milk containing the same percentage of fat.

We will illustrate these statements first by seeing what happens when we add enough cream to normal 3 per cent fat milk to make it into an adjusted milk containing 4 per cent of fat.

	FAT	SOLIDS-NOT-FAT	RATIO OF FAT TO SOLIDS-NOT-FAT
	per cent	*per cent*	
Normal milk containing	3	8.60	1:2.87
Normal milk containing	4	9.10	1:2.27
Adjusted milk containing	4	8.60	1:2.15

Here, in the case of the normal 3 per cent fat milk, made into standardized 4 per cent fat milk, we see that, while the fat increases to 4 per cent, the solids-not-fat remain at 8.60 per cent just as in the normal 3 per cent fat milk. The adjusted milk contains the fat of 4 per cent milk but the solids-not-fat of normal 3 per cent fat milk. Such standardized milk has less food value by ½ pound of solids-not-fat per 100 pounds of milk than is contained in normal milk containing 4 per cent of fat. The ratio of fat to solids-not-fat is reduced fom 2.27 to 2.15 for 4 per cent fat milk, normal and standardized.

Let us take one more illustration, adjusting normal 3 per cent fat milk to standardized milk containing 5 per cent of fat.

	FAT	SOLIDS-NOT-FAT	RATIO OF FAT TO SOLIDS-NOT-FAT
	per cent	*per cent*	
Normal milk containing	3	8.60	1:2.87
Normal milk containing	5	9.50	1:1.90
Standardized milk containing	5	8.60	1:1.72

We have here in more exaggerated form results similar to those obtained in the preceding illustration. The adjusted milk contains 5 per cent of fat, but only 8.60 per cent of solids-not-fat instead of 9.50 per cent of solids-not-fat, which is the amount that normally goes with milk containing 5 per cent of fat. The ratio of fat to solids-not-fat drops from 1.90 in the normal milk to 1.72 in the standardized milk.

Summarizing the results which have been presented in showing the effect of standardizing or adjusting milk upon the composition, we have seen:

1. When we decrease the percentage of fat in normal milk by removal of cream or by addition of skim-milk, we readjust not only the percentage of fat but particularly the ratio or proportion of fat to the other milk solids. This readjustment has the effect, it may be said, of standardizing or adjusting the solids-not-fat *up* in relation to fat.

2. When we increase the percentage of fat in normal milk by the addition of cream, we readjust the ratio or proportion of fat to solids-not-fat in such a way that we standardize or adjust the solids-not-fat *down* in relation to fat.

3. When we standardize or adjust milk by reducing the percentage of fat, we increase somewhat the food value of the milk in solids-not-fat in comparison with normal milk containing the same percentage of fat as the standardized or adjusted milk. Thus, for example, standardized 3 per cent fat milk, made from 4 per cent fat milk, has somewhat more food value in solids-not-fat than has normal 3 per cent fat milk.

4. When we adjust or standardize milk by addition of cream, we decrease somewhat the food value of the milk in solids-not-fat in comparison with normal milk containing the same percentage

of fat as the adjusted or standardized milk. Thus, for example, standardized or adjusted 4 per cent fat milk, made by adding cream to 3 per cent fat milk, has somewhat less food value in solids-not-fat than has normal 4 per cent fat milk.

2. RELATIONS OF STANDARDIZATION OF MILK TO PRODUCERS, DISTRIBUTORS AND CONSUMERS

Producers who sell milk to distributors may have little or no interest in the standardization of milk. However, it is probable that some questions now unforeseen might develop, affecting the interests of such producers. Those producers who sell milk directly to consumers might find it to their advantage to standardize their milk, especially when their herds may produce milk below the minimum legal standard. It would also be of advantage when milk of fairly uniform fat content is desired by one's customers. It is probable, however, that standardization would be made use of by producers only in exceptional instances.

The desire to introduce the practice of standardizing or adjusting milk comes mainly from distributors who handle large amounts of milk gathered from an extended territory for the purpose of supplying cities. The milk which they purchase from individual producers varies more or less widely in composition, especially in percentage of fat. Under present methods of mixing milk in a haphazard way, the milk distributed to consumers varies more or less in composition. If standardization is permitted, a product of much greater uniformity in percentage of fat can be furnished. Further, in case at any time a large amount of normal milk should drop below the minimum legal standard of 3 per cent of fat, the milk before distribution can easily be brought above such standard by adjusting. Again, dealers who desire to furnish regularly to customers milk above a definite guaranteed percentage of fat can do so more conveniently by means of standardization than is possible under present conditions.

In relation to consumers, standardization of milk is a matter of practical interest. It would be practicable for them to obtain milk

of a more uniform composition and also of any definite composition in milk-fat whether 3, 4, 5 or other percentage were desired.

These statements indicate some of the more obvious and important relations that standardization of milk bears to the three parties interested.

3. ADVANTAGES AND OBJECTIONS IN RELATION TO STANDARDIZATION OF MILK

The more obvious advantages that would result from the standardization of market milk have just been stated under the preceding heading. Are there any disadvantages or objections? There may be.

1. Without some kind of legal control, the result of standardizing or adjusting market milk would be the inevitable tendency to lower the composition of such milk to a point not much above the minimum legal standard, at present 3 per cent of fat and 11.50 per cent of milk solids in New York State. Market milk would not only tend to become fairly uniform the year around instead of varying as it now does, but unfortunately the uniformity would be in the direction of a lower percentage of fat than now prevails. The high value of milk-fat in the form of cream would exist as a constant temptation to standardize nearly all normal milk above 3.50 per cent of fat to a lower fat content.

2. Milk cannot be standardized or adjusted without extra handling and this results in exposure to possible bacterial contamination. Without special care in manipulating milk when going through the process of standardization, the sanitary character may easily be unfavorably affected.

3. In the case of milks enriched by the addition of cream, the consumer gets somewhat less food value in solids-not-fat than he would in buying normal milk having the same percentage of fat. However, this difference is hardly large enough to constitute a serious objection.

4. There is on the part of many consumers a vague feeling of objection to having anything done to market milk that affects its composition; and such persons think that standardizing should not be permitted under any conditions. For many years we have been careful to surround normal market milk with jealous

legal protection and until recently to recognize as legal the sale only of normal milk whatever its composition. Many have thus come unconsciously to regard normal milk, that is the milk produced by the cow, as something the composition of which should not be tampered with in any way, indeed, as something having an almost sacred kind of character. Of course, this is largely a matter of psychology rather than of dairy intelligence. We know that the composition of much normal market milk can be improved in some ways by standardization.

5. Objection is likely to be made to the standardization of milk on the ground that the disturbance of the ratio of fat to solids-not-fat may have objectionable results in connection with the feeding of infants. This objection has little force when we consider the manifold ways in which normal milk is "modified" for infant feeding, producing changes in composition much more extensive than take place when milk is standardized. On the other hand, standardization should result in greater uniformity of composition, a condition especially desired in case of milk for infants.

4. LEGAL CONTROL OF STANDARDIZATION OF MARKET MILK

All who have devoted any thought to the subject of adjusted or standardized milk are agreed (1) that promiscuous, uncontrolled standardization should not be considered under any circumstances; (2) that, if such treatment of milk is permitted it should be controlled by law as completely as practicable; (3) that this must be done in order to prevent the obviously objectionable conditions which would result from lack of such control.

Among the more important conditions that would be necessary to make standardization safe are the following:

(1) No one should be permitted to prepare standardized milk for market purposes without a special state license.

(2) Such conditions of standardizing processes should be prescribed as would insure no impairment of the sanitary quality of the milk.

(3) No standardized or adjusted milk should be permitted to be sold unless it conforms to the present legal minimum requirements in composition (3 per cent of fat and 11.50 per cent of

solids). There are some who suggest that the minimum standard for standardized milk be placed at 3.25 per cent of fat and 12 per cent of solids.

(4) Some believe that all containers of such milk should be marked with the words "standardized" or "adjusted." There may be an honest difference of opinion as to whether this is necessary or desirable. Use of the word "standardized" on containers might easily be misleading to consumers as referring to superior quality, while the word "adjusted" might readily arouse unwarranted suspicion.

(5) Whatever other safeguards it may be judged desirable to place around the standardization of market milk and its sale, the belief cannot be expressed too strongly that *it is all-important to place on every container of standardized or adjusted milk in plain figures the minimum percentage of fat in milk*, which shall stand as a guaranty that the milk in the container contains not less than the specified amount of milk-fat. This would accomplish several important purposes, among which, briefly stated are the following:

1. It would serve as a check to prevent adjusting the fat in all market milk down close to the present legal minimum standard of 3 per cent.

2. It would enable every consumer of such milk to know the minimum percentage of fat in each lot of milk purchased.

3. It would afford an opportunity for each consumer to purchase milk with the approximate percentage of fat desired, within reasonable limits, if there were any choice, and it would make it easily possible for the distributor or producer to furnish it.

4. It would protect distributors and producers against unfair competition.

5. It would have the tendency of helping to adjust or standardize the price of market milk in accordance with the composition of the milk furnished.

6. The successful employment of such a method would probably have the ultimate effect of making the sale of milk on a guaranteed fat basis supersede entirely the present minimum legal standard method for all kinds of milk, whether normal or adjusted.

ABSTRACTS AND REVIEWS OF DAIRY LITERATURE

City Milk Supply. HORATIO NEWTON PARKER. 468 pp. The McGraw-Hill Book Company, Inc., New York.

Instructors in city milk supply have long felt the need of a complete and up to date text book on the subject. Many of the books on various dairy subjects are really encyclopedias, covering many branches of the dairy industry, thereby making them poorly adapted to the teaching of one particular branch of the industry. Parker's City Milk Supply is, for the most part at least, an exception.

The author approaches the subject in a way which convinces the student of the importance of the dairy industry, of the great value of milk as a food and of the magnitude of the milk business. He then deals with the necessity of the sanitary production and handling of milk on the farm. The presentation of the facts relative to the diseases communicable in milk is exceptionally good. All the factors which affect the quality of milk at the time of milking and after the milk is drawn are fully discussed.

In only one place does the author diverge from the subject and present some information ordinarily covered in another course. This is in Chapter III, the first part of which discusses the various types and breeds of dairy cattle.

Having explained the sanitary production of milk, the course of the milk from the time it leaves the farmer until it reaches the consumer is carefully mapped out. The various means of transportation are described. The chapter entitled, "The Milk Contractor," comprising 142 pages treats fully with all the problems of the city milk plant. The treatise on pasteurization is up to date and thorough. Finally the various methods of controlling the chemical and sanitary requirements of the milk supply are discussed.

Not the least attractive feature is that at the end of each chapter there is a bibliography of the books and bulletins drawn upon for parts of the information contained in the chapter. This is a great aid to the instructor in assigning outside written work. The book is printed on an excellent grade of paper and contains sixty-three well chosen cuts. It is most sure to fill the needs of a course in "City Milk Supply."—H. F. JUDKINS.

The "Kingston" Cheese—A Cheese for Small-holders and Others. ALEX TODD AND WILFRID SADLER. Journal, Bd. of Agr., vol. xviii, no. 3, pp. 193–203, London, 1911.

The system adopted in making a small hard-pressed cheese, varying from 1 to 2 pounds in weight is described. By this system, a cheese is produced suitable for an average family; a cheese which embraces the qualities of a hard-pressed variety and yet one which is ripe and ready for consumption in ten to fifteen days after making. It may, however, if trade considerations demand, be kept in storage under suitable conditions for as long as six weeks. Since the outbreak of war, this cheese with others has been recommended by the English Board of Agriculture as a suitable variety to be made by those formerly making butter on the farms, as one means of food conservation.

The experimental work was carried out at the Midland Agricultural and Dairy College, Kingston, Derby, England.

Qualities. The cheese is a little softer than a Cheddar, and has a characteristic flavour; the texture is soft and granular embodying the features of a Cheshire and a Leicester, while to the touch it is soft and buttery; on boring with a trier, the fatty, smeary nature so typical of a mellow old cheese, is evident.

Utensils. The utensils required are in general those common in a cheese-making dairy or factory; if such need to be purchased, the initial outlay at pre-war prices averages about ten dollars per cow for a small dairy.

Process of making. Starter is added to the milk at the rate of 0.5 to 1 per cent. If a coloured cheese is desired, 1 ounce annatto to 400 pounds milk is desirable. A twenty-five second rennet test has given good results; at this acidity, and at a temperature of 84°F., rennet is added at the rate of 2½ ounces to 1000 pounds milk. When the coagulum is cut, the pieces of curd should be about ½ by ¼ inch. After cutting, the curd is left in the whey for some fifteen minutes before the cooking commences. The scalding or cooking must be gradual and the final temperature should be 90°F. Stirring is continued until the curd is sufficiently firm, when it is allowed to pitch. Usually the time from cutting to pitching will be one and one-quarter to one and one-half hours. The curd remains in the whey for twenty to thirty minutes; and when the acidimeter test is 0.15 to 0.16 per cent, the whey is drawn off. The curd is cut into 4 inch cubes, piled, covered with cloths, and left for fifteen minutes. Again the curd is cut into similar cubes, turned in bulk and each cube broken into halves; this assists in the

expulsion of the whey, and has considerable influence on the 'short' texture so much desired in the final product. The turning and breaking is practised two or three times, but this is dependent upon the condition of the curd as regards dryness and acidity. No pressure is applied, as the curd must not be allowed to 'matt' as in a cheddar.

When ready for grinding, the test on the hot iron is about $\frac{3}{4}$ inch, or the acidimeter test 0.5 per cent, this stage is usually reached one hour after the drawing of the whey. The curd at this stage is soft and velvety to the touch, and should break short, with no tendency to toughness. It is milled to a fine state, and on pressing a handful of curd it should be moist, mellow, and free, with a smaller amount of excess moisture than a Derby, yet more than is required in a Cheddar curd. Salt is added at the rate of 1 ounce to 3 pounds curd, and moulding is done at once; the weight of curd will vary, but the average yield is $1\frac{1}{4}$ pounds to $1\frac{1}{3}$ pounds per gallon of milk. The cheese are at once put under press, the acidity on the acidimeter being 0.5 to 0.6 per cent. The moulds are made of well-tinned metal, 4 inches in height, diameter $3\frac{1}{2}$ inches, the bottom of the mould is closed except for a hole in the centre $1\frac{1}{2}$ inches diameter; a loose tin follower is used in the bottom and a wooden follower is needed to cover the curd at the top.

The cheese are left under press for two hours with the dead weight of the press applied; they are then turned and pressed again for a further two hours with a little additional weight. The pressure is released, the cheese again turned, and allowed to remain in the moulds for some eighteen or twenty-four hours. They are then smoothed up with a palette knife and bandaged with calico and paste, or if more convenient they may be smoothed up and paraffined. The cheese are removed to the ripening room; good results have been obtained by ripening at a temperature of 60° to 65°F. when the cheese are required to mature in ten days. If they need to be kept for a longer period, they must be removed after the first few days, to a cool or cold room. Usually one pound of ripe cheese is produced per gallon of milk.—WILFRID SADLER.